UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

APR 04 2006

In Response Refer To:
151422SWR2004SA9121:JSS

Brandon C. Muncy
Chief, Planning Division
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Muncy:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological and conference opinion (Enclosure 1) based on our review of the proposed Stockton Deep Water Ship Channel (DWSC) Maintenance Dredging and Levee Stabilization project in Contra Costa, Sacramento, and San Joaquin Counties, California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), proposed threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). Your April 15, 2005, request for section 7 consultation on maintenance dredging for the Stockton DWSC and levee stabilization was received on May 31, 2005. A response was sent to the U.S. Army Corps of Engineers (Corps) on June 30, 2005, indicating that we concurred with your determination that the proposed project was likely to adversely affect the above listed and proposed species and designated critical habitats, and that formal consultation would be required for this project. NMFS requested additional information from the Corps to describe the fisheries monitoring and water quality monitoring programs included in the Corps' project description. Final drafts of the plans for the fisheries monitoring and water quality monitoring programs have not been completed; therefore, NMFS has analyzed the effects of the project without relying on monitoring efforts to avoid or minimize effects on listed species.

This biological and conference opinion is based on information provided in the March 25, 2004, section 7 consultation initiation package which included: the biological assessment (BA) for the proposed project; supplemental information to the BA delivered on August 20, 2004, and April 15, 2005; letters and e-mails regarding the proposed project received by NMFS staff; meetings held January 29, 2003, August 24, 2004, January 20, 2005, and August 4, 2005, regarding the project and agency concerns; and, numerous scientific articles and reports from both the peer reviewed literature and agency "gray literature." A complete administrative record of this consultation is on file at the Sacramento Area Office of NMFS.

Based on the best available scientific and commercial information, the biological and conference opinion concludes that the Stockton DWSC Maintenance Dredging and Levee Stabilization project, as proposed by the Corps, is not likely to jeopardize the continued existence of the listed or proposed species or adversely modify designated critical habitat. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take associated with the project. The conference opinion concerning the proposed listing of green sturgeon does not take the place of consultation under section 7(a) 2 of the ESA. The conference opinion may be adopted as a biological opinion when the proposed listing for the southern DPS of North American green sturgeon becomes final if no significant new information is developed, and no significant changes to the project are made that would alter the contents of this opinion.

This letter also transmits NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha*), starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the Stockton DWSC Maintenance Dredging and Levee Stabilization project will adversely affect the EFH of Pacific salmon, starry flounder, and English sole in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the biological and conference opinion as the EFH conservation recommendations.

The Corps has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation Recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 (j)). If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response.

Please contact Mr. Jeffrey Stuart in our Sacramento Area Office at (916) 930-3607 or via e-mail at J.Stuart@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)
1. Biological and Conference Opinion
2. Essential Fish Habitat Conservation Recommendations

cc: James Starr, California Department of Fish and Game, 4001 North Wilson Way, Stockton, CA 94205

Ryan Olah, U.S. Fish and Wildlife Service, 2800 Cottage Way, Room W-2605, Sacramento, CA 95825

Sue McConnell, Central Valley Regional Water Quality Board, Sacramento Main Office, 11020 Sun Center Drive, Suite #200, Rancho Cordova, CA 95670-6114

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BIOLOGICAL AND CONFERENCE OPINION

ACTION AGENCY: U.S. Army Corps of Engineers, Sacramento Engineer District

ACTIVITY: Stockton Deep Water Ship Channel Maintenance Dredging and Levee Stabilization Project

CONSULTATION CONDUCTED BY: Southwest Region, National Marine Fisheries Service

FILE NUMBER: 151422SWR2004SA9121:JSS

I. CONSULTATION HISTORY

On January 29, 2003, John Baker and Jeff Stuart of NOAA's National Marine Fisheries Service (NMFS) met with Jim Sanders, Randy Olsen, and Monica Eichler of the Sacramento Engineer District, U.S. Army Corps of Engineers (Corps) to discuss process and informational requirements for section 7 consultations on maintenance dredging for the Sacramento Deep Water Ship Channel (DWSC) and San Joaquin DWSC.

On March 25, 2004, the Corps submitted a biological assessment (BA) and request for concurrence that the proposed maintenance dredging and bank stabilization work was not likely to affect listed species or critical habitat.

On April 29, 2004, NMFS responded to the Corps request with a finding that all information necessary to concur with the Corps determination had not been provided. Additional information was requested from the Corps. The requested information included a complete description of the proposed action including identification of individual reaches to be dredged and maintenance dredging cycles, sediment analysis data, water quality analysis data for both dredging operations and effluent return from dredge material placement (DMP) sites, a description of the specific areas to be affected directly or indirectly, and a description of the manner in which the action may affect listed species or designated critical habitat.

On August 20, 2004, the Corps submitted a supplemental BA to address the comments made by NMFS in their April 29, 2004, letter requesting additional information.

On August 24, 2004, a meeting was held between staff from NMFS (Jeff Stuart) and the Corps (Michael Finan, Monica Eichler, Randy Olsen, and Josh Garcia) to discuss the needs of the Corps for dredging operations and the needs of NMFS for assessing environmental impacts related to the project and associated effects upon listed salmonids. The Corps withdrew their request for formal consultation for the 2004 dredging cycle.

On January 20, 2005, a meeting was held between staff from NMFS (Jeff Stuart) and the Corps (Monica Eichler and Kimberly Moir) to discuss the development of the supplemental information and data required by NMFS for the section 7 consultation. Jeff Stuart provided an outline of potential impacts to listed salmonid species and aquatic habitat to the Corps to aid Corps staff in their development of the supplemental BA.

NMFS Sacramento Area Office received a copy of the supplemental BA and the Corps' request for initiation of formal consultation under section 7 of the Endangered Species Act (ESA) on May 31, 2005. NMFS responded to the Corps request on June 30, 2005, and initiated formal consultation.

On August 4, 2005, a meeting was held between staff from NMFS (John Baker and Jeff Stuart) and the Corps (Kimberly Moir and Mike Dietl) to discuss the fish monitoring and water quality monitoring plans to be developed by the Corps as part of their project description.

On October 24, 2005, NMFS responded to a request by the Corps for concurrence that proposed maintenance dredging activities scheduled for October 21, 2005, through December 31, 2005, were not likely to adversely affect endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), and threatened Central Valley steelhead (*O. mykiss*), or their designated critical habitat. NMFS concurred with the Corps determination based in part on the limited locations specified for dredging after November 15, 2005.

II. DESCRIPTION OF THE PROPOSED PROJECT

The Corps proposes to continue to perform routine maintenance dredging and bank protection on the Stockton DWSC under an Indefinite Delivery/Indefinite Quantity yearly contract during the 10 dredging seasons from 2006 to 2015. These actions are authorized by the Rivers and Harbors Act of October 27, 1965, (Public Law 89-298, 89th Congress, 1st Session). The Stockton DWSC is a maintained portion of the San Joaquin River that serves as a commercial shipping lane between Pittsburgh, California, and the Port of Stockton in Stockton, California (Figure 1). The Port is situated on the San Joaquin River between river miles (RM) 37.5 and 41. The DWSC extends downstream for 37 miles to the City of Antioch, where the dredged ship channel leaves the main channel of the San Joaquin River at RM 4 and follows New York Slough to its mouth on the Sacramento River near the City of Pittsburg.

A. Project Activities

1. <u>Dredging</u>

The proposed maintenance dredging project will maintain the Stockton DWSC at a depth of -35-feet mean lower low water (MLLW) plus 1-foot allowable overdredge. The width of the dredged channel invert elevation varies from as little as 200 feet to as much as 600 feet. Over the course of the 10-year dredging program, the annual dredging cycle will occur between June 1 and December 31. The average dredging cycles for the different reaches of the Stockton DWSC are presented in Table 1.

Table 1: Average Dredging Cycles for the Stockton DWSC- Antioch to Stockton

Reach (river miles)	Dredging Cycle (years)
8 to 12	4
13 to 15	17
15 to 16	10.7
29 to 35	11
37 to 41	3.5

Such cycles are only averages so that dredging in any reach may occur in any given year because depositional mechanisms are not predictable and maintenance dredging occurs every year in some portion of the DWSC. The sequence of reaches dredged each year would be specified in the annual task order. Unless otherwise specified in the task order, dredging would start at the downstream most reach and proceed sequentially to the upstream most reach. Dredging within a reach may proceed in any direction provided it is done in a progressive and complete manner (Corps 2003b). The Corps does not anticipate that more than 500,000 cubic yards would be dredged annually.

The Corps proposes to use a hydraulic suction dredge with a cutterhead to perform its maintenance dredging operations. The suction dredge is powered by a 2,000 horsepower (hp) hydraulic pump which pulls water through the cutterhead at velocities up to 11 feet per second. The dredge material forms a slurry (85 percent water, 15 percent substrate material) which is transported through a 16-inch diameter discharge pipe. Future dredges may be smaller or larger in terms of size; however, there is a limit to how much larger the dredges could be due to the limitations of the required settling times for dredge material placed in the DMP sites. The constraints on settling time are implemented in order to meet the water quality criteria required by the Central Valley Region of the California Regional Water Quality Control Board (Regional Board). The additional volume and rate of discharge inherent in larger dredges would tend to exceed the design capacity of the DMP sites and discharge from the sites would occur before the required settling times had elapsed. The quantity of material to be dredged each dredging season would not exceed 500,000 cubic yards, barring monumental flood events. The quantity of material to be dredged each working day during maintenance dredging operations would not exceed 8,576 cubic yards as required by the Waste Discharge Requirements (WDRs) General Order No. R5-2004-0061 issued by the Regional Board (*i.e.*, based on a 16-inch dredge pumping 6,944 gallons per minute, which is the 10 million gallons per day limit set by the General Order) (Corps 2003a). The dredge is expected to operate 24 hours per day, 7 days per week.

The cutterhead dredge is generally equipped with two stern spuds (pivot pipes) used to hold the dredge in its working position and to advance the dredge into the next cut or excavating area. During operation, the cutterhead swings from side to side alternately using the port and starboard spuds as a pivot. Cables attached to anchors on either side of the dredge control its lateral movement and help “walk” the dredge forward (Corps 1983). Dredging operations will continue for several days at a time on a 24-hour schedule. However, the actual dredging intake pipeline will only function for approximately 8 to 10 hours per day, with the remainder of the time filled with maintenance and logistical operations to keep the dredge in operating condition and to move the dredge barge from site to site along the DWSC.

The dredge slurry will be pumped from the dredge sites along either the north or south shore of the DWSC to the nearest DMP site. The pipeline will be slightly buoyant and be constructed of durable plastic material. It will be designed to float approximately 2 inches above the water's surface when empty and will sink to the bottom when filled with the dredge slurry mixture. The anticipated route of the pipeline will position it outside of the channel of the DWSC to avoid impinging on commercial shipping traffic. Notes to mariners and navigational warning markers will be used as needed to prevent navigational hazards for recreational boaters

Dredging activities would be limited to depths greater than 20 feet, and the cutterhead would be kept within 3 feet of the channel bottom while drawing in water. The cutterhead is mounted on a "ladder" that is free to pivot in the vertical plane and is rotated down to various depths. The ladder is mounted on a floating dredge that swings left and right while proceeding along the channel. The dredge is transported to the area by a tugboat, or the dredge could be self-propelled. Typically, the dredge is tended by two tenders of the 750-hp class that pick up and place the swing anchors as the dredge progresses and can move the dredge short distances. There are also two outboard engine-powered skiffs that transport crews and conduct the water sampling upstream and downstream of the dredge.

2. <u>Dredge Material Placement Sites</u>

The DMP sites that are identified as potential sites for the placement of dredge spoils from the maintenance dredging actions are identified in Table 2 and their locations given in Figures 2a and 2b. DMP sites are engineered confinement basins that hold the dredge slurry until the material has settled out of suspension. The DMP site is generally engineered with high earthen berms surrounding the perimeter of the site to contain a designated slurry volume. Within the basin, training berms or weirs are constructed to direct the flow of water and suspended material away from the inflow point and towards the discharge weir or pump in a manner which maximizes the settling time. The intent of the design is to minimize or eliminate turbidity and suspended material in the decant water (Corps 1987). If the volume of decant water is excessive, then it is discharged back into the surrounding waterways to provide more space for additional dredge slurry. Alternatively, if the volume of dredged slurry is small, the entire volume of material can be retained within the DMP site and allowed to dry with no discharge of decant water back into surrounding waterways. Dried dredge material can be reused beneficially if they are considered uncontaminated. Such beneficial uses include providing material for levee reinforcement or upland fill, constructing wetland features in habitat restoration sites, or returning the DMP site to non-food cropping (*e.g.*, alfalfa for livestock feed).

In addition to the above named DMP sites, Jersey Island contains a site that potentially may be utilized as a placement site. This site is approximately 375 acres in size and has a capacity of 1.2 million cubic yards. Effluent could leave this site in two different ways, either by gravity flow into an agricultural return ditch and then pumping over the levee into the San Joaquin River, or by direct pumping into the San Joaquin River from the DMP site.

Table 2: Stockton DWSC DMP Sites

Site Name	Approximate Size (acres)	Effluent Return	Ownership	Special Requirements
Port of Stockton (S-4) Class 1-E Site	99	Gravity Drain – Water leaves site by existing weirs	Port of Stockton	High exterior levees with past stability problems
Roberts Island I Class I Site	250	Pump	Port of Stockton	May be under cultivation
Roberts Island II Class I Site	220	Pump	Port of Stockton	May be under cultivation
Spud Island Class II Site	10	Gravity Drain – Water leaves site by existing weir box	Port of Stockton	Only access is by boat
Bradford Island Class II Site	121	Pump – Water leaves site by gravity into an agricultural return ditch which contractor must then pump out	Port of Stockton and Reclamation District (RD) 2059	Only access is by boat; agricultural return ditch is pumped out by RD 2059/ Port of Stockton owned pumps
McCormick Pit Class I Site	51	Pump – Water leaves site by gravity into an agricultural return ditch, pump out provided by RD 341 pumps (15,000 gpm)	California Department of Water Resources and RD 341	Site is underlain by peat soils
Expanded Scour Pit Class I Site	125	Pump – Water leaves site by gravity into an agricultural return ditch which contractor must then pump out	California Department of Water Resources and RD 341	Site is underlain by peat soils; no placement of decant waters into ponds onsite

Each DMP site typically is located within 3 miles of the river reach to be dredged. Distances in excess of this require additional booster pumps to move the slurry of dredge material to the DMP site, which increases the complexity and cost of the dredging operation.

3. Levee Stabilization

The bank protection maintenance work will be conducted along the banks of the Stockton DWSC between June 15 and November 30 each year from 2006 to 2015. The Corps is authorized to provide maintenance levee work within 1,000 feet of the centerline of the channel, and for this consultation it will include the river reaches between RM 4 and RM 41 (Antioch to Stockton, California). Rock will only be placed at sites that previously contained bank protection work and where there is a need to supplement the rock cover due to bank erosion.

Activities in shallow water will be avoided to the fullest extent; however, there is the potential that some work may involve work in shallow water habitat by necessity.

Suitable rock protection would be placed at eroded sites on the waterside of the levees, as identified during annual inspections by the Corps. If an erosion site no longer has evidence of pre-existing rock and would therefore require placing rock on a site with fish habitat in the form of vegetation, the Corps would mitigate, at a 3:1 ratio, for any beneficial habitat values that have developed over the passage of time.

Rock protection will be placed by mechanical means on the affected levee face, typically via a barge-mounted clamshell crane, or if road access is available, by dump truck and mobile crane. Rock material will be placed above the MLLW during low tide events. This will prevent stone material from being placed below the water surface during the stabilization activity and creating unintended turbidity plumes. Stone used as bank protection riprap will be placed in such a manner as to create a uniform grade up the levee face with a minimum percentage of large voids. Rearranging of the stone riprap face by dragline may be required to remove protruding stones and create a reasonably smooth levee face. At no time will heavy equipment such as bull dozers or graders be allowed to work on the levee face. Dumping of stone riprap material over the levee crest to fill in the face will not be permitted.

4. <u>Interrelated and Interdependent Activities</u>

The proposed project will maintain the Stockton DWSC as a commercial shipping lane between Pittsburg and the Port of Stockton. Therefore, shipping is interrelated and interdependent with the proposed project. Present shipping levels are estimated to average 0.4 to 0.7 commercial vessels per day. Additionally, the proposed Port of Stockton, West Complex Redevelopment project is anticipated to increase shipping levels to 0.9 to 1.2 commercial vessel transits per day in the future, and is expected to result in larger ships transiting the DWSC (see the *Environmental Baseline* section).

B. Proposed Conservation Measures

The following conservation measures have been proposed by the applicant as part of the project description (Corps 2005) for the 10-year Stockton DWSC Maintenance Dredging and Levee Stabilization project.

1. All decant water will be monitored for Regional Board constituents of concern and physical parameters. Management practices will include placing flash boards at the spillway of DMP sites to increase the retention time, using interior dikes within the DMP sites to increase the hydraulic efficiency of the DMP site, and varying the dredge production rates (Corps 2003a). Decant water will only be discharged to the river if it meets all of the water quality standards stated in the Regional Board WDR General Order. If the water does not meet the standards, then it will be retained on the relevant DMP site until further analyses reveal such compliance. The effluent would not exceed water quality orders or criteria for any constituent that is on the Clean Water Act section 303(d) list.

2. The effects to water quality will further be minimized by not allowing:

   a. concentrations of effluent dissolved oxygen (DO) to fall below 5.0 mg/L;

   b. release of oils, grease, waxes, or other materials that could form a visible film or coating on the water surface or on the stream bottom or creating a nuisance or adversely affecting beneficial uses;

   c. fungi, slime, or other objectionable growths, or esthetically undesirable discoloration;

   d. operations-induced pH at points of compliance to fall below 6.5, to exceed 8.5, or to change by more than 0.5 pH units;

   e. operations-induced temperature increase of more than 5 °F (Corps 2003a); or

   f. any spills of hazardous materials to remain in the waters of the United States. All spills would be cleaned up immediately and reported in compliance reports.

3. Changes in turbidity will comport with the following water quality criteria:

   a. If undisturbed turbidity is between 0 and 5 nephelometric turbidity units (NTU), increases will not exceed 1.0 NTU;

   b. If undisturbed turbidity is between 5 and 50 NTU, increases will not exceed 20 percent of the original value;

   c. If undisturbed turbidity is between 50 and 100 NTU; increases will not exceed 10 NTU; and

   d. If undisturbed turbidity is greater than 100 NTU, increases will not exceed 10 percent of original value.

4. The measurement of total suspended solids (TSS) will be made and reported under a contract that specifies a rapid turnaround time and reporting. All DMP sites will have a limitation of 100 mg/L for TSS concentration in the effluent discharged to the surrounding surface waters. It may be necessary to mound or stack material so that the maximum ponding area of the DMP site is used.

5. Direct effects to listed salmonids by entrainment will be avoided by not raising the hydraulic cutterhead more than 3 feet off the river bottom when the pumps are operating.

6. The contractor will be responsible for providing erosion and sediment control measures in accordance with Federal, State, and local laws and regulations to ensure compliance with water quality standards. This will be accomplished by installing temporary and permanent erosion and sediment control materials or structures using best management practices (BMPs). These may include, but are not limited to, vegetation cover, stream bank

stabilization, slope stabilization, silt fences, terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. Any temporary materials or structures will be removed after the area has been stabilized (Corps 2003b).

7. A Corps representative will be identified as the point of contact for any contractor who might incidentally take a listed steelhead or Chinook salmon species, or find a dead, injured, or entrapped listed steelhead or Chinook salmon. This point of contact will be identified to all construction employees during an orientation training session regarding the potential effects on listed steelhead and Chinook salmon species. The orientation will be conducted by a qualified fisheries biologist and cover specific information on measures to prevent injury to listed fish and what to do if any are found in the project area.

8. NMFS will be notified immediately if a listed Chinook salmon or steelhead is found dead or injured within the dredging action area. Follow-up written notification will include the date, time, and location of the dead or injured specimen, a photograph, cause of injury or death, and name and agency affiliation of the individual who found the specimen.

9. The Corps, through the dredging contractors, will minimize adverse effects associated with the loss of riparian habitat by mitigation with no net loss of quantity or quality. This will be coordinated with NMFS.

10. Additional hydraulic dredging practices included in the conservation measures include reducing the rotation speed of the cutterhead which minimizes the amount of substrate material sidecast or resuspendend into the overlying water column and reducing the speed of the arm swing which ensures that the cutterhead is not moving faster than its ability to pump the dredge material, and that all of the removed material is pulled into the orifice of the dredge intake pipe.

11. Dredging at depths of less than 20 feet will be avoided at all times by the dredge operator.

12. Suction to the cutterhead will not be employed until the cutterhead is on the bottom.

13. The dredge material pipeline will be placed in such a manner as to avoid adverse effects to both submerged aquatic vegetation and riparian habitat. The point at which the dredge material pipeline crosses the levee and discharges into the DMP site will be the position at which the pipeline is securely fixed to the levee so that the pipeline will not drag along the levee.

14. Overflow or bypass from the dredge into the channel will not be allowed.

15. The use of a drag beam or similar piece of equipment to knock down high spots or ridges in the channel bottom will be prohibited.

16. The Corps proposes to draft and implement a monitoring plan to evaluate the nature and extent of effects on listed anadromous salmonids and green sturgeon. The Corps has not previously implemented monitoring plans for fish during dredging operations. A qualified

fisheries biologist will perform real-time monitoring in the channel and/or at the point of discharge into the DMP site to assess entrainment of fish species, including listed salmonids. Monitoring will occur on an annual basis until there is sufficient data to allow for the quantification of incidental take, as dictated by NMFS' review of the data.

C. Action Area

The action area is defined as all of the areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area for the purposes of this biological opinion includes those portions of the San Joaquin River from RM 4 to RM 41, including the portion of the Port of Stockton known as the Turning Basin. This segment of the San Joaquin River passes through portions of Contra Costa, Sacramento, and San Joaquin counties. The direct and indirect effects of the proposed project are anticipated to encompass the entire width of the river channel from levee to levee, along the 37 mile reach defined above.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed and proposed species (ESUs or DPSs) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU
endangered (June 28, 2005, 70 FR 37160)

Central Valley spring-run Chinook salmon ESU
threatened (June 28, 2005, 70 FR 37160)

Central Valley steelhead DPS
threatened (January 5, 2006, 71 FR 834),

Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
proposed threatened (April 6, 2005, 70 FR 17386)

The designated critical habitat of Sacramento River winter-run Chinook salmon occurs at the origin of the DWSC adjacent to Kimball, Browns and Winter Islands near RM 4 of the San Joaquin River and is inclusive of the aquatic habitat below the ordinary high water mark surrounding these islands. Designated critical habitat for Central Valley spring-run Chinook salmon borders the northern edge of the San Joaquin River from the confluence of the Mokelumne River west to the boundaries of the Suisun Bay and Sacramento Delta hydrologic sub units at approximately RM 4 of the San Joaquin River. This would include the waters of Three Mile Slough and New York Slough. Individuals of both Chinook salmon ESUs can occupy waters within the DWSC action area. Designated critical habitat for the Central Valley steelhead DPS occurs along the entire length of the DWSC below the ordinary high water mark.

A. Species and Critical Habitat Listing Status

NMFS has recently completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and concluded the species' status should remain as previously listed (70 FR 37160). On January 5, 2006, NMFS published a final listing determination for ten steelhead DPSs (71 FR 834), including Central Valley steelhead. The new listing concludes that Central Valley steelhead will remain listed as threatened.

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. Critical habitat was delineated as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. The critical habitat designation identifies those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration and protection. Within the Sacramento River this includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. In the areas west of Chipps Island, including San Francisco Bay to the Golden Gate Bridge, this designation includes the estuarine water column, essential foraging habitat, and food resources utilized by winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the Central Valley spring-run Chinook salmon ESU as of June 28, 2005 (70 FR 37160). Critical habitat was designated for spring-run Chinook salmon in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta.

Central Valley steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations are now included in the listed population of steelhead (71 FR 834; these populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population). Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta.

The southern DPS of North American green sturgeon was proposed for listing as threatened on April 6, 2005 (70 FR 17386). The southern DPS presently contains only a single spawning population in the Sacramento River; individuals may occur in the action area. No critical habitat has been designated or proposed for the southern DPS of North American green sturgeon.

B. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

a. *General Life History*

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 ºF to 56 ºF (Bell 1991, California Department of Fish and Game (CDFG) 1998). Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Adult spring-run Chinook salmon enter the Delta from the Pacific Ocean beginning in January and enter natal streams from March to July (Myers *et al.* 1998). In Mill Creek, Van Woert (1964) noted that of 18,290 spring-run Chinook salmon observed from 1953 to 1963, 93.5 percent were counted between April 1 and July 14, and 89.3 percent were counted between April 29 and June 30. Typically, spring-run Chinook salmon utilize mid- to high elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (U.S. Fish and Wildlife Service (FWS) 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Bell (1991) identifies the preferred water temperature for adult spring-run Chinook salmon migration as 38 ^{o}F to 56 ^{o}F. Boles (1988) recommends water temperatures below 65 ^{o}F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 ^{o}F, and that fish can become stressed as temperatures approach 70 ^{o}F. The Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 ^{o}F; although, salmon can tolerate temperatures up to 65 ^{o}F before they experience an increased susceptibility to disease. The upper preferred water temperature for spawning Chinook salmon is 55 ^{o}F to 57 ^{o}F (Chambers 1956, Bjornn and Reiser 1995). Winter-run Chinook salmon spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and RBDD (Vogel and Marine 1991). The majority of winter-run Chinook salmon spawners are 3-years old. Physical Habitat Simulation Model (PHABSIM) results (FWS 2003a) indicate winter-run Chinook salmon suitable spawning velocities in the upper Sacramento River are between 1.54 feet per second (ft/s) and 4.10 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter. Initial habitat suitability curves (HSCs) show spawning suitability rapidly decreases for water depths greater than 3.13 feet (FWS 2003a). Spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994). PHABSIM results indicate spring-run Chinook salmon suitable spawning velocities in Butte Creek are between 0.8 ft/s and 3.22 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter (FWS 2004). The initial HSC showed suitability rapidly decreasing for depths greater than 1.0 feet, but this effect was most likely due to the low availability of deeper water in Butte Creek with suitable velocities and substrates rather than a selection by spring-run Chinook salmon of only shallow depths for spawning (FWS 2004).

The optimal water temperature for egg incubation is 44 ^{o}F to 54 ^{o}F (Rich 1997). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The length of time required for eggs to develop and hatch is dependent on water temperature and is quite variable. Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61 ^{o}F and 37 ^{o}F, respectively, when the incubation temperature was held constant.

Winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al.* 1981). Post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration. Emigration of juvenile winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). The emigration timing of Central Valley spring-run Chinook salmon is highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Within the

Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54 ºF to 57 ºF (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 ºF by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

As Chinook salmon fry and fingerlings mature, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healy 1980, 1982; Levings *et al.* 1986). Juvenile winter-run Chinook salmon occur in the Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities (CDFG 1998). The peak of listed juvenile salmon arrivals in the Delta generally occurs from January to April, but may extend into June. Upon arrival in the Delta, winter-run Chinook salmon spend the first 2 months rearing in the more upstream, freshwater portions of the Delta (Kjelson *et al.* 1981, 1982). Data from the CVP and SWP salvage records indicate that most spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 2000).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1986) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Winter-run Chinook salmon fry remain in the estuary (Delta/Bay) until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age) and then begin emigrating to the ocean perhaps as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998). Little is known about estuarine residence time of spring-run Chinook salmon. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry. Spring-run yearlings are larger in size than fall-run yearlings and are ready to smolt upon entering the Delta; therefore, they are believed to spend little time rearing in the Delta.

b. *Population Trend – Sacramento River Winter-run Chinook Salmon*

The distribution of winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and, optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989; NMFS 1997, 1998). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

Following the construction of Shasta Dam, the number of winter-run Chinook salmon initially declined but recovered during the 1960s. The initial recovery was followed by a steady decline from 1969 through the late 1980s following the construction of the RBDD. Since 1967, the estimated adult winter-run Chinook salmon population ranged from 117,808 in 1969, to 186 in 1994 (FWS 2001a, b; CDFG 2002b). The population declined from an average of 86,000 adults in 1967 to 1969 to only 1,900 in 1987 to 1989, and continued to remain low, with an average of 2,500 fish for the period from 1998 to 2000 (see Appendix B: Figure 3). Between the time Shasta Dam was built and the listing of winter-run Chinook salmon as endangered, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, acid mine drainage from Iron Mountain Mine, and entrainment at a large number of unscreened or poorly-screened water diversions (NMFS 1997, 1998).

Population estimates in 2001 (8,224), 2002 (7,441), 2003 (8,218), and 2004 (7,701) show a recent increase in the escapement of winter-run Chinook salmon. The 2003 run was the highest since the listing. Winter-run Chinook salmon abundance estimates and cohort replacement rates since 1986 are shown in Table 3. The population estimates from the RBDD counts have increased since 1986 (CDFG 2004a), there is an increasing trend in the 5-year moving average (491 from 1990-1994 to 5,451 from 1999-2003); and, the 5-year moving average of cohort replacement rates has increased and appears to have stabilized over the same period (Table 3).

Table 3. Winter-run Chinook salmon population estimates from RBDD counts, and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, Grand Tab CDFG February 2005).

Year	Population Estimate (RBDD)	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated Juvenile Production Estimate (JPE)[a]
1986	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,831,286
median	1,769	1,550	1.78	2.49	338,107

[a]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

c. *Status - Sacramento River Winter-run Chinook Salmon*

Numerous factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing, and migration habitats. The primary impacts include blockage of historical habitat by Shasta and Keswick Dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates, and entrainment in a large number of unscreened or poorly screened water diversions within the Central Valley. Secondary factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, and interactions with, and predation by, introduced non-native species (NMFS 1997, 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperatures objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CALFED) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn-Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account (EWA); (6) Environmental Protection Agency (EPA) actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

The susceptibility of winter-run Chinook salmon to extinction remains linked to the elimination of access to most of their historical spawning grounds and the reduction of their population structure to a small population size. Recent trends in winter-run Chinook salmon abundance and cohort replacement are positive and may indicate some recovery since the listing. Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0.

d. *Population Trend – Central Valley Spring-run Chinook Salmon*

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon, which occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers extirpated Central Valley spring-run Chinook salmon from these watersheds. Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag

(CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally-spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993 (CDFG unpublished data). Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Appendix B: Figure 4). The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2002 and 2003, total run size for the ESU was 13,218 and 8,775 adults respectively, well above the 1991-2001 average.

Evaluating the ESU as a whole masks significant changes that are occurring among basin metapopulations. For example, while the mainstem Sacramento River population has undergone a significant decline, the tributary populations have demonstrated substantial increases. The average population abundance of Sacramento River mainstem spring-run Chinook salmon has recently declined from a high of 12,107 fish for the period 1980 to 1990, to a low of 609 for the period between 1991 and 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same period. Although tributaries such as Mill and Deer Creeks have shown positive escapement trends since 1991, recent escapements to Butte Creek, including 20,259 in 1998, 9,605 in 2001, and 8,785 in 2002, are responsible for the overall increase in tributary abundance (CDFG 2002a, 2004b; CDFG, unpublished data). The Butte Creek estimates, which account for the majority of this ESU, do not include prespawning mortality. In the last several years as the Butte Creek population has increased, mortality of adult spawners has increased from 21 percent in 2002 to 60 percent in 2003 due to over-crowding and diseases associated with high water temperatures. This trend may indicate that the population in Butte Creek may have reached its carrying capacity (Ward *et al.* 2003) or has reached historical population levels (*i.e.*, Deer and Mill creeks). Table 4 shows the population trends from the three tributaries since 1986, including the moving 5-year average, cohort replacement rate, and estimated JPE.

Table 4. Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2005) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated JPE[a]
1986	24,263	-	-	-	4,396,998
1987	12,675	-	-	-	2,296,993
1988	12,100	-	-	-	2,192,790
1989	7,085	-	0.29	-	1,283,960
1990	5,790	12,383	0.46	-	1,049,277
1991	1,623	7,855	0.13	-	294,124
1992	1,547	5,629	0.22	-	280,351
1993	1,403	3,490	0.24	0.27	254,255
1994	2,546	2,582	1.57	0.52	461,392
1995	9,824	3,389	6.35	1.70	1,780,328
1996	2,701	3,604	1.93	2.06	489,482
1997	1,431	3,581	0.56	2.13	259,329
1998	24,725	8,245	2.52	2.58	4,480,722
1999	6,069	8,950	2.25	2.72	1,099,838
2000	5,457	8,077	3.81	2.21	988,930
2001	13,326	10,202	0.54	1.94	2,414,969
2002	13,218	12,559	2.18	2.26	2,395,397
2003	8,902	9,9394	1.63	2.08	1,613,241
2004	9,872	10,155	0.74	1.78	1,789,027
2005	14,312	11,926	1.08	1.23	2,593,654
median	7,994	9,172	1.33	1.74	1,448,601

[a]NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, and assuming a female to male ratio of 6:4 and prespawning mortality of 25 percent. NMFS utilized the female fecundity values in Fisher (1994) for spring-run Chinook salmon (4,900 eggs/female). The remaining survival estimates used the winter-run values for calculating JPE.

The extent of spring-run Chinook salmon spawning in the mainstem of the upper Sacramento River is unclear. Very few spring-run Chinook salmon redds (less than 15 per year) were observed from 1989 through1993, and none in 1994, during aerial redd counts (FWS 2003a). Recently, the number of redds in September has varied from 29 to 105 during 2001 though 2003 depending on the number of survey flights (CDFG, unpublished data). In 2002, based on RBDD ladder counts, 485 spring-run Chinook salmon adults may have spawned in the mainstem Sacramento River or entered upstream tributaries such as Clear or Battle Creek (CDFG 2004b). In 2003, no adult spring-run Chinook salmon were believed to have spawned in the mainstem Sacramento River. Due to geographic overlap of ESU and resultant hybridization since the construction of Shasta Dam, Chinook salmon that spawn in the mainstem Sacramento River during September are more likely to be identified as early fall-run rather than spring-run Chinook salmon.

e. *Status of Spring-run Chinook Salmon*

The initial factors that led to the decline of spring-run Chinook salmon in the Central Valley were related to the loss of upstream habitat behind impassable dams. Since this initial loss of habitat, other factors have contributed to the instability of the spring-run Chinook salmon population and have negatively affected the ESU's ability to recover. These factors include a combination of physical, biological, and management factors such as climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and over-harvesting (CDFG 1998). Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures.

During the drought from 1986 to 1992, Central Valley spring-run Chinook salmon populations declined substantially. Reduced flows resulted in warm water temperatures that impacted adults, eggs, and juveniles. For adult spring-run Chinook salmon, reduced instream flows delayed or completely blocked access to holding and spawning habitats. Water management operations (*i.e.*, reservoir release schedules and volumes) and the unscreened and poorly-screened diversions in the Sacramento River, Delta, and tributaries compounded drought-related problems by reducing river flows, elevating river temperatures, and entraining juveniles into the diversions.

Several actions have been taken to improve habitat conditions for spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist. Because the Central Valley spring-run Chinook salmon ESU is confined to relatively few remaining watersheds and continues to display broad fluctuations in abundance, the population is at a moderate risk of extinction.

2. <u>Steelhead</u>

a. *General Life History*

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Winter steelhead generally leave the ocean from August through April, and spawn between December and May (Busby *et al.* 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. In general, the preferred water temperature for adult steelhead migration is 46 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). Thermal stress may occur at temperatures beginning at 66 ^{o}F and mortality has been demonstrated at temperatures beginning at 70 ^{o}F, although some races of steelhead may have higher or lower temperature tolerances depending upon their evolutionary history. Lower latitudes and elevations would tend to favor fish tolerant of higher ambient temperatures (see Matthews and Berg (1997) for discussion of *O. mykiss* from Sespe Creek in Southern California). The preferred water temperature for steelhead spawning is 39 ^{o}F to 52 ^{o}F, and the preferred water temperature for steelhead egg incubation is 48 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972). Preferred water velocity for upstream migration is in the range of 40-90 cm/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 240 cm/s (Thompson 1972, Smith 1973).

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992, Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Most steelhead spawning takes place from late December through April, with peaks from January though March (Hallock *et al.* 1961). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity, and may spawn in intermittent streams as well (Everest 1973, Barnhart 1986).

The length of the incubation period for steelhead eggs is dependent on water temperature, DO concentration, and substrate composition. In late spring, following yolk sac absorption, fry emerge from the gravel and actively begin feeding in shallow water along stream banks (Nickelson *et al.* 1992).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Shirvell 1990, Meehan and Bjornn 1991). Some older juveniles move downstream to rear in large tributaries and mainstem rivers (Nickelson *et al.* 1992). Juveniles feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey upon emerging fry.

Steelhead generally spend 2 years in freshwater before emigrating downstream (Hallock *et al.* 1961, Hallock 1989). Rearing steelhead juveniles prefer water temperatures of 45 EF to 58 EF and have an upper lethal limit of 75 EF. They can survive up to 81 EF with saturated DO conditions and a plentiful food supply. Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/L for successful rearing of juvenile steelhead. During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/L permit good rearing conditions for juvenile salmonids.

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Barnhart (1986) reported that steelhead smolts in California range in size from 140 to 210 mm (fork length). Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall.

b. *Population Trend – Central Valley Steelhead*

Steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). The California Advisory Committee on Salmon and Steelhead (1988) reported a reduction of steelhead habitat from 6,000 miles historically to 300 miles currently. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996).

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially (see Appendix B: Figure 5). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River.

Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2003) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. In the *Updated Status Federally Listed ESUs of West Coast Salmon and Steelhead* (Good *et al.* 2005), the Biological Review Team (BRT) made the following conclusion based on the Chipps Island data:

> "If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data (see Appendix B, Figure 6) indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2003, a total of 12 steelhead smolts were collected at Mossdale (CDFG, unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, as reported in Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (Demko *et al.* 2000). After 3 years of operating a fish counting weir on the Stanislaus River only two adult steelhead have been observed moving upstream, although several large rainbow trout (*O. mykiss*) have washed up on the weir in late winter (S.P. Cramer 2005). It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005).

c. *Status - Central Valley Steelhead*

Both the BRT (Good *et al*. 2005) and the Artificial Propagation Evaluation Workshop (69 FR 33102) concluded that the Central Valley steelhead DPS presently is "in danger of extinction". Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DPS focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks. Because the Central Valley steelhead population has been fragmented into smaller isolated tributaries without any large source population and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

3. Southern Distinct Population Segment of North American Green Sturgeon

a. *General Life History*

(1) *Adult Distribution and Feeding*. In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005a). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et* al 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Recent acoustical tagging studies on the Rogue River (Erickson *et al*. 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15 ^{o}C and 23 ^{o}C. When ambient temperatures in the river dropped in autumn and early winter (< 10 ^{o}C) and flows increased, fish moved downstream and into the ocean.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, J. Stuart, NMFS, pers. obs.). Adult sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

(2) *Spawning*. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon sexual maturity). Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van

Eenennaam *et al*. 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The eggs are less adhesive and more dense than than those of white sturgeon (Kynard *et al.* 2005). Green sturgeon adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005).

(3) ***Egg Development.*** Green sturgeon larvae hatched from fertilized eggs after approximately 169 hours at a water temperature of 15 ^{o}C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14 ^{o}C and 17 ^{o}C. Temperatures over 23 ^{o}C resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5 ^{o}C and 22 ^{o}C resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14 ^{o}C, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

(4) ***Early Development.*** Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. The larvae are less developed in their morphology than older juveniles and external morphology resembles a “tadpole” with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation. Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al*. 2002).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other A*cipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.’s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 ^{o}C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15 ^{o}C and 19 ^{o}C under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath River systems range from 4 ^{o}C to approximately 24 ^{o}C. The Sacramento River has similar temperature profiles, and, like the Rogue and Klamath Rivers, is a regulated system with several dams controlling flows on its mainstem (Shasta and Keswick Dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus Dams).

Larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolomieui*) have been recorded on the Rogue River as preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005). This latter study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

b. *Population Trend –Southern DPS of North American Green Sturgeon*

Based on the distribution of sturgeon eggs, larvae, and juveniles the in the Sacramento River, CDFG (2002c) indicated that southern DPS of green sturgeon spawn in late-spring and early-summer above Hamilton City possibly to Keswick Dam. Young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002c). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging in fork length from 24 to 31 mm (CDFG 2002c). Sampling efforts at Glen Colusa Irrigation District on the Sacramento River yield green sturgeons averaging approximately 29 mm in length with a peak abundance occurring in July (Adams 2002). Since 1980, trawling studies in the San Francisco Bay estuary and Delta have taken a total of 61 juvenile green sturgeon ranging in size from 20 to 112 cm total length and although most juveniles are captured between April and October, they have been captured in nearly every month of the year (CDFG 2002c, IEP Relational Database search May 31, 2005). Juveniles spend between 1 and 4 years in fresh and estuarine waters and enter the marine environment at lengths of approximately 300 mm (Adams 2002).

Spawning in the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate upstream to spawning areas now blocked by the dam which was constructed in 1968. Due to the extreme longevity of green sturgeon (and sturgeon in general), it is possible that these adults represent adults which have previously spawned in the Feather River system prior to the construction of the dam.

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and Central Valley steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Population abundance information concerning the southern DPS of North American green sturgeon is scant as described in the status review (Adams 2002). Limited population abundance information comes from incidental captures of green sturgeon from the white sturgeon (*Acipenser transmontanus*) monitoring program by the CDFG sturgeon tagging program (CDFG 2002c). CDFG (2002c) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile green sturgeon per year, mostly between June and July (Adams 2002). The only existing information regarding changes in the abundance of the southern DPS of green sturgeon includes changes in their abundance at the John Skinner Fish Protection Facility between 1968 and 2001 (SWP facility). The estimated number of green sturgeon taken at the SWP Facility prior to 1986 was 732; since 1986, the average number has dropped to 47 (70 FR 17386). For the Tracy Fish Collection Facility (CVP facility), the average number prior to 1986 was 889; from 1986 to 2001 the average has dropped to 32 (70 FR 17386). In light of the increased volume of water exports, particularly during the previous 10 years, it is apparent that green sturgeon population abundance is dropping. Catches of sub-adult and adult green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the proportion of the southern DPS of North American green sturgeon is unknown due to the comingling of the Northern and Southern population segments in San Pablo Bay. Additional analysis of green and white sturgeon taken at the SWP and CVP facilities indicates that take of both green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386).

c. *Status –Southern Distinct Population Segment of North American Green Sturgeon*

The southern DPS of North American green sturgeon historically was smaller than the sympatric population of white sturgeon in the San Francisco Bay estuary and its associated tributaries. The population has apparently been declining over the past several decades based on harvest numbers from sport and commercial fisheries and the entrainment rates at the CVP and SWP. The principle factor for this decline is the reduction of green sturgeon spawning habitat to a limited area below Keswick Dam on the Sacramento River. The construction of impassable barriers, particularly large dams, has greatly reduced the access of green sturgeon to their historical spawning areas. Reduced flows have corresponded with weakened year class recruitment in the sympatric white sturgeon population and it is believed to have the same effect upon green sturgeon recruitment. In addition to the adverse effects of impassable barriers, numerous agricultural water diversions exist in the Sacramento River and the Delta along the migratory route of larval and juvenile sturgeon. Entrainment, or, if equipped with a fish screen, impingement are considered serious threats to sturgeon during their downstream migration. Fish screens have not been designed with criteria that address sturgeon behavior or swimming capabilities. The benthic oriented sturgeon are also more susceptible to contaminated sediments through dermal contact and through their feeding behavior of ingesting prey along with contaminated sediments before winnowing out the sediment. Their long life spans allow them to accumulate high body burdens of contaminants, that potentially will reach concentrations with deleterious physiological effects. All of the above threats have been identified by the BRT as potentially affecting the continued existence of the southern DPS of North American green strurgeon (70 FR 17386).

C. Factors Affecting the Species and Critical Habitat

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for West coast Chinook salmon (Myers *et al.* 1998), steelhead (Busby *et al.* 1996) and green sturgeon (Adams *et al*. 2002, NMFS 2005a). Also, the NMFS BRT published an updated status review for West coast Chinook salmon and steelhead in June 2005 (Good *et al*. 2005). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212, 59 FR 440, 62 FR 24588, 62 FR 43937, 63 FR 13347, 64 FR 24049, 64 FR 50394, 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Bay-Delta Program (CALFED 1999), and the Final Programmatic EIS for the CVPIA (Department of Interior (DOI) 1999), provide an excellent summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley.

The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, the southern DPS of North American green sturgeon, and their habitat is based on a summary of these documents.

In general, the human activities that have affected listed anadromous salmonids, proposed North American green sturgeon, or their habitats consist of: (1) dam construction that blocks previously accessible habitat; (2) water development and management activities that affect water quantity, flow timing, quality, and stream function; (3) land use activities such as agriculture, flood control, urban development, mining, road construction, and logging that degrade aquatic and riparian habitat; (4) hatchery operation and practices; (5) harvest activities; and, (6) ecosystem restoration actions.

1. <u>Habitat Blockage</u>

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid-1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River (DOI 1999). On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon (CDFG 2001) as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967). These dams also had the potential to block any spawning populations of green sturgeon in these tributaries.

As a result of the dams, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations on these rivers have been confined to lower elevation mainstems that historically only were used for migration. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adults and juvenile salmonids. Green sturgeon populations would be similarly affected by these barriers and alterations to the natural hydrology.

The Suisun Marsh Salinity Control Gates (SMSCG), located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, California Department of Water Resources (DWR) 2002). The effects of the SMSCG on sturgeon are unknown at this time.

2. <u>Water Development</u>

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year-round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation.

These stable flow patterns have reduced bedload movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (FWS 2003b).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and, (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.). Entrainment of green sturgeon at the CVP/SWP export facility is known to occur as well.

3. <u>Land Use Activities</u>

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The degradation and fragmentation of riparian habitat had resulted mainly from flood control and bank protection projects, together with the conversion of riparian land to agriculture. Removal of snags and driftwood in the Sacramento and San Joaquin River basins has reduced sources of LWD needed to form and maintain stream habitat that salmon depend on for various life stages.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is a primary cause of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and, removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc*. Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999).

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley.

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years have shown a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a decline in the phytoplankton and zooplankton abundance. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

4. Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Regional Board, in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they: interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways; decrease neurological function; degrade cardiovascular output; and act as mutagens, teratogens or carcinogens in exposed organisms (Rand *et al*. 1995, Goyer 1996). For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995).

Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids or the proposed threatened green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids to contaminated sediments is similar to water borne exposures.

5. <u>Hatchery Operations and Practices</u>

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (DOI 1999). For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento

River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally-produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally-produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally-spawning fish in the short term under specific scenarios, artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally-spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

6. Commercial and Sport Harvest

a. *Ocean Harvest*

(1) *Chinook salmon*. Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent.

Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). There are limited data on spring-run Chinook salmon ocean harvest rates. An analysis of 6 tagged groups of FRH spring-run Chinook salmon by Cramer and Demko (1997) indicated that harvest rates of 3-year-old fish ranged from 18 percent to 22 percent, 4-year-old fish ranged from 57 percent to 84 percent, and 5-year-olds ranged from 97 percent to 100 percent. The almost complete removal of 5-year-olds from the population effectively reduces the age structure of the species, which reduces its resiliency to factors that may impact a particular year class (*e.g.*, prespawning mortality from lethal instream water temperatures).

(2) *Steelhead*. There is essentially no ocean harvest of steelhead.

(3) *Green sturgeon*. Ocean harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. A commercial fishery for sturgeon still exists within the Columbia River, where they are caught in gill nets along with the more commercially valuable white sturgeon. Green sturgeon are also caught by recreational fisherman, and it is the primary bottomfish landed in Willapa Bay. Within the San Francisco Bay estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun Bays (Emmett *et al*. 1991).

b. *Freshwater Sport Harvest*

(1) *Chinook salmon.* Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on winter-run Chinook salmon caused by recreational angling in freshwater.

In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, holding adult spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

(2) *Steelhead*. There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. Staley (1975) estimated the harvest rate in the American River during the 1971-1972 and 1973-1974 seasons to be 27 percent. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams (CDFG 2004c). Overall, this regulation has greatly increased protection of naturally-produced adult steelhead.

(3) *Green sturgeon.* Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. Due to slot limits imposed on the sport fishery by the California DFG, only sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. This protects both fish that are sexually immature and have not yet had an opportunity to spawn, and those larger females that have the greatest reproductive value to the population.

7. <u>Predation</u>

Accelerated predation also may be a factor in the decline of winter-run Chinook salmon and spring-run Chinook salmon, and to a lesser degree steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson Cottonwood Irrigation District's diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall (Vogel *et al.* 1988). In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters.

FWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally-eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the State and Federal fish facilities, and the SMSCG. Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

8. <u>Environmental Variation</u>

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El NiZo condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west.

During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a subadult life stage.

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Predation rates on juvenile and adult green sturgeon have not been adequately studied to date. Ocean predation may also contribute to significant natural mortality, although it is not known to what extent. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations following their protection under the Marine Mammal Protection Act of 1972 has increased the number of salmonid deaths.

Unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g.*, winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall. Green sturgeon's need for appropriate water temperatures would also benefit from river operations that maintain a suitable temperature profile for this species.

The future effects of global warming are of key interest to salmonid and green sturgeon survival. It is predicted that Sierra snow packs will dwindle with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be rationally hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods. Similar, although potentially to a lesser degree, declines in green sturgeon populations are anticipated with reduced cold-water flows. Green sturgeon egg and larval development are optimized at water temperatures that are only slightly higher than those for salmonids. Lethal temperatures are similar to salmonids, although slightly higher than those for salmonids.

9. Ecosystem Restoration

a. *California Bay-Delta Authority*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP Program have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Bay in conjunction with tidal wetland restoration.

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in south Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and splittail. However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

b. *Central Valley Project Improvement Act*

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward recovery of all anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the DOI's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for spring-run Chinook salmon and steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

c. *Iron Mountain Mine Remediation*

EPA's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a state-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s (see Appendix J, Reclamation 2004). Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

d. *State Water Project Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement)*

The Four Pumps Agreement Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreement inception in 1986. Four Pumps projects that benefit spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Bay upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead (see Chapter 15, Reclamation 2004).

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin

River basins. These two enhanced enforcement programs have had significant, but unquantified benefits to spring-run Chinook salmon attributed to CDFG (see Chapter 15, Reclamation 2004).

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District (OCID), CDFG, and DWR allows DWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cfs, only 12 cfs has been developed to date (Reclamation and OCID 1999). In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek (Reclamation and OCID 1999). In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. DWR, CDFG, and FWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

10. <u>Non-native Invasive Species</u>

As currently seen in the San Francisco estuary, non-native invasive species (NIS) can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants has certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

Land-use activities such as road construction, urban development, logging, mining, agriculture, and recreation are pervasive and have significantly altered fish habitat quantity and quality for Chinook salmon and steelhead through alteration of streambank and channel morphology;

alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and, removal of riparian vegetation resulting in increased streambank erosion. Human-induced habitat changes, such as: alteration of natural flow regimes; installation of bank revetment; and, building structures such as dams, bridges, water diversions, piers, and wharves, often provide conditions that both disorient juvenile salmonids and attract predators. Harvest activities, ocean productivity, and drought conditions provide added stressors to listed salmonid populations. In contrast, various ecosystem restoration activities have contributed to improved conditions for listed salmonids (*e.g.*, various fish screens). However, some important restoration activities (*e.g.*, Battle Creek) have not yet been initiated. Benefits to listed salmonids from the EWA have been smaller than anticipated.

D. Critical Habitat Condition and Function for Species' Conservation

The freshwater habitat of salmon, steelhead, and sturgeon in the Sacramento River, San Joaquin River, and Suisun Marsh watershed drainages varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water quality are found. Freshwater spawning sites are primary constituent elements (PCEs) of critical habitat for salmonids. The condition of spawning habitat is greatly affected by factors such as water temperature, DO, and silt load, which can greatly affect the survival of eggs and larvae. High quality spawning habitat is now inaccessible behind large dams in these watersheds, which limits salmonids to spawning in marginal tailwater habitat below the dams. Despite often intensive management efforts, the existing spawning habitat below dams is highly susceptible to inadequate flows and high temperatures due to competing demands for water, which impairs the habitat function.

Freshwater migration corridors and estuarine areas also are PCEs of critical habitat. They are located downstream of spawning habitat and include the Delta and Suisun Marsh. These areas allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are impaired in each of these drainages by the presence of barriers, which can include dams, unscreened or poorly-screened diversions, inadequate water flows, and degraded water quality.

Freshwater rearing sites for juveniles, which feed and grow before and during their outmigration, are PCEs of critical habitat. Non-natal, intermittent tributaries also may be used for juvenile rearing by salmonids, but such use has not been documented for sturgeon. Rearing habitat condition is strongly affected by factors such as water quantity and quality, and the availability of natural cover and food, which allow juveniles to grow and avoid predators. Some complex, productive habitats with floodplains remain in the Sacramento and San Joaquin River systems (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and the Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Delta and Suisun Marsh systems typically have low food abundance and low cover availability, and offer little protection from either fish or avian predators.

IV. ENVIRONMENTAL BASELINE

A. Factors Affecting the Species and Habitat in the Action Area

Starting in the mid-1800s, the Corps and other private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bedload in the riverine system as well as the local flow velocity in the channel (Mount 1995). The Sacramento Flood Control Project at the turn of the nineteenth century ushered in the start of large scale Corps actions in the Delta and along the rivers of California for reclamation and flood control. The creation of levees and the Sacramento and San Joaquin DWSCs reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations during the wet winter season and the spring snow melt periods. These annual inundations provided necessary habitat for rearing and foraging of juvenile native fish that evolved with this flooding process. The armored riprapped levee banks and active maintenance actions of reclamation districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWD from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Low DO levels frequently are observed in the portion of the DWSC extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the Port of Stockton, West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/L DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed Central Valley steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A, Table 5).

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970). As the river water and its constituents move downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 8 to 10 feet to over 35 feet. The water column is no longer mixed adequately to prevent DO from decreasing by contact with the air–water interface only. Photosynthesis by suspended algae is diminished by increased turbidity and circulation below the photosynthetic compensation depth. This is the depth to which light penetrates with adequate intensity to carry on photosynthesis in excess of the oxygen demands of respiration. As the oxygen demand from respiration, defined as biological oxygen demand, exceeds the rate at which oxygen can be produced by photosynthesis and mixing, then the level of DO in the water column will decrease. Additional demands on oxygen are also exerted in non-biological chemical reactions in which compounds consume oxygen in an oxidation-reduction reaction.

NMFS completed consultation on the Port of Stockton, West Complex Dredging project on July 19, 2005 (NMFS Project No. 151422SWR2003SA9009;9010JSS; NMFS 2005b). The Port is situated on the San Joaquin River between RM 37.5 and RM 41. The proposed Port of Stockton, West Complex Dredging project will involve dredging approximately 576,000 cy of material from the waters of the San Joaquin River, adjacent to the Port's wharves at the West Complex. Disposal of this material will occur at the DMP site on Roberts Island, which also will be used to facilitate dredge material disposal associated with the project that is the focus of the present consultation. The dredging activities are anticipated to exacerbate the low DO conditions in the DWSC. However, the Port of Stockton, West Complex Dredging project is a part of a much larger action, called the West Complex Redevelopment project as described in the Port's draft EIR for the project (Environmental Science Associates 2003). Interrelated and interdependent activities include upland development of the former naval facilities on Rough and Ready Island with the intent of accommodating larger ships compared to those that currently use the DWSC. This development will result in an approximate doubling of ship traffic in the San Joaquin River. Hence, these activities will affect the entire action area of the project that is the subject of the present consultation.

In addition to the adverse effects of dredging and release of effluent from the DMP site, the Port of Stockton, West Complex Dredging project is expected to adversely affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead transiting the action area through increased shipping impacts including, but not limited to, propeller entrainment and changes in channel hydrodynamics (*e.g.*, creation of shear forces and turbulent mixing created by vessel passage).

The total incidental take associated with the Port of Stockton, West Complex Dredging project was estimated by NMFS as follows:

Species	Juveniles		Adults	
	Number	Percent of ESU/DPS	Number	Percent of ESU/DPS
Sacramento River winter-run Chinook salmon:	2,500	0.80	0	0
Central Valley spring-run Chinook salmon:	5,000	0.32	0	0
Central Valley Steelhead:	280	0.15	3	0.15

NMFS's biological opinion on the Port of Stockton, West Complex Dredging project (NMFS 2005b) did not assess the project's effects on the southern DPS of North American green sturgeon. However, NMFS (2005b) states the following:

> Recent discussions with CDFG staff have indicated that adult sturgeon have been recovered with obvious propeller scars, some resulting in death, during fish monitoring surveys (Gingras 2005). These incidents occurred immediately following the passage of large ocean going ships in the San Joaquin River channel.

The expected increase in shipping notwithstanding, this statement suggests that the ongoing impact of shipping at present levels likely is adversely affecting listed and proposed species.

B. Presence of Listed Salmonids in the Action Area

The action area for the maintenance dredging of the Stockton DWSC stretches between the terminus of the dredged DWSC at the turning basin (RM 41) and RM 4 of the San Joaquin River near Pittsburg, California. Channel Point is considered the juncture between the DWSC and the upper river sections of the San Joaquin River. All of the listed Central Valley steelhead in the San Joaquin River watershed originating from the Calaveras, Stanislaus, Tuolumne, or Merced Rivers must pass through the Stockton DWSC on both their downstream emigration to the ocean as smolts and on their upstream spawning migrations as adults. Those few adults that survive to spawn a second time would also pass through this portion of the river again. There is the potential for fish to make their way through either Old River or Middle River to access the upper San Joaquin watershed above the Head of Old River, but their success depends on whether or not the Head of Old River Barrier is in place. Smolts are more likely than adults to stay within the mainstem during their migrations, as they follow the prevailing current out to the ocean. Upstream migrating adults have the option of following either the Sacramento River or San Joaquin River upon their entry into the Delta. This co-mingling of water sources can result in milling behavior as fish seek out the olfactory cues of their natal stream.

Based on fish monitoring studies, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles and smolts from the Sacramento River watershed frequently enter into the San Joaquin River system based on river flows and SWP and CVP pumping rates. Fish from the Sacramento River can access the San Joaquin River from several points, the Delta Cross Channel via the North and South Forks of the Mokelumne River, Georgiana Slough, Three Mile Slough, and the mouth of the San Joaquin River near Antioch and Sherman Island. Fish entering into the San Joaquin River main channel would be exposed to the effects of this project while they migrated within the DWSC. In addition, adults of these ESUs or DPS would also be exposed to the conditions of the DWSC if they entered into the San Joaquin River channel by mistake while trying to find their way upstream.

C. Presence of North American Green Sturgeon in the Action Area

Both adult and juvenile North American green sturgeon are known to occur within the lower reaches of the San Joaquin River and in the south Delta. Juveniles have been captured in the vicinity of Santa Clara Shoals and Brannan Island State Recreation Area, and in the channels of the south Delta (Moyle *et al*. 1992, Beamesderfer *et al*. 2004). Green sturgeon also have been recovered at both the SWP and CVP pumping facilities on Old River near Tracy, indicating that they must have transited through one of the many channels of the south Delta to reach that location. Both adult and juvenile green sturgeon may use the Delta as a migratory, resting, or rearing habitat. Green sturgeon presence in the Delta could occur in any month, as juveniles may reside there during their first few years of growth. Adults are likely to be present in the winter and early spring as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed. Following spawning, the fish will pass through the Delta again on their way back to the ocean, but the duration and timing of this event is not well understood in the Sacramento River system.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological and conference opinion assesses the effects of the Corps' Stockton DWSC Maintenance Dredging and Levee Stabilization project on endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, proposed threatened southern DPS of North American green sturgeon, and their designated critical habitats. The proposed action is likely to adversely affect listed salmonids, North American green sturgeon, and their habitat primarily through the action's proposed dredging activities in the DWSC, effluent from the DMP sites following placement of dredge spoils into them, and the impacts of stabilizing and repairing the levees lining the San Joaquin River between RM 4 and RM 41. Interrelated and interdependent activities related to the proposed actions will cause additional adverse effects to listed fish, primarily due to shipping activities (*i.e.* propeller entrainment and hull hydrodynamics) supported by the DWSC maintenance dredging. In the *Description of the Proposed Action* section of this opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this opinion, NMFS provided an overview of the threatened and endangered species and critical habitats that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(a)(2) of the ESA require that biological opinions evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536, 50 CFR §402.02).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed actions on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response, including behavioral reactions, to these effects. These responses then will be assessed to determine if they can reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

The regulatory definition of adverse modification has been invalidated by the courts. Until a new definition is adopted, NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species.

A. Approach to Assessment

1. Information Available for the Assessment

To conduct the assessment, NMFS examined an extensive amount of evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, scientific meetings, and environmental reports submitted by the project proponents. Additional information investigating the effects of the project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was obtained from the aforementioned resources. Final drafts of the plans for the fisheries monitoring and water quality monitoring programs proposed as part of the project have not been completed; therefore, NMFS has analyzed the effects of the project without relying on monitoring efforts to avoid or minimize effects on listed species.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

In assessing the impacts of anthropogenic noise on the listed salmonid species, NMFS used the available data for several different species of fish for which acoustic experimental data is available, including the hearing specialist, fathead minnow (*Pimephales promelas*) and the hearing generalist, pink snapper (*Pagrus auratus*). Protective acoustic levels were then determined that were appropriate for fish in general, due to the lack of data specific to salmonids. In a recent review of available information on the effects of anthropogenic sound (*i.e.*, pile driving) generated by construction activities on the west coast of North America, Hastings and Popper (2005) specifically cited the lack of salmonid data as a critical gap in the scientific record for evaluating noise impacts, and recommended increased and focused studies on this group of fish.

Additional information from fish monitoring studies conducted by the FWS and CDFG regarding salmonid density in the San Joaquin River and Sacramento River was incorporated into the calculations for risk assessment. Turbidity effects utilized information pertaining to salmonids in general, rather than to the specific listed species present in the action area due to a lack direct information concerning their response.

B. Assessment

The Corps' maintenance dredging actions will occur for 10 dredging seasons (*i.e.*, from June 1 through December 31) from 2006 to 2015. Dredging at a particular location is expected to occur intermittently, with an average dredging cycle of 3 to 4 years between actions for some highly accreting areas, while other sections may be dredged less than once per decade. Bank stabilization will occur between June 15 and November 30 each year for the 10-year duration of this opinion. Bank sections deemed in need of repair will be restored to their original configuration during the in-water work window designated in the project description. Project impacts on listed salmonids and North American green sturgeon are expected to include both direct impacts to fish present in the action area during the activities, and indirect impacts that may occur later in time and adversely affect fish occurring through the action area at any time of the year. Direct adverse effects are expected to result from re-suspension of sediment and toxic chemicals, entrainment (including that of benthic food organisms), and noise generated from dredging activities, effluent return from DMP sites, or bank stabilization work. Long-term, indirect effects are expected to result from impacts to habitat such as bathymetry changes or the removal of vegetation or the ramifications of shipping traffic in the maintained channel.

1. <u>Presence of Listed Salmonids and Proposed North American Green Sturgeon in the Action Area</u>

During the period between September and the end of December, Central Valley adult steelhead may be in the proximity of the dredging and bank stabilization activities as proposed; however, NMFS expects the most likely period for them to be present is in the month of December. Adult steelhead begin to migrate into the region's watersheds (Calaveras and San Joaquin Rivers) during this period, particularly when increased attractant flows are being released by San Joaquin River reservoirs to enhance fall-run Chinook salmon spawning runs in the San Joaquin River tributaries or early winter rains create increased flows in the system. Prior to the fall attractant flows, low DO conditions may occur and cause adult steelhead to linger downstream of the Port of Stockton while they wait for more favorable water quality conditions.

The peak of juvenile Central Valley steelhead emigration from their tributaries in the San Joaquin Valley occurs during the period between February and May. Therefore, conducting project activities between June 1 and December 31 should avoid impacts to the majority of juvenile Central Valley steelhead smolts in this locale. There are, however, larger steelhead smolts that migrate at other times of the year, including the fall and early winter period (S.P. Cramer 2005), and thus may be exposed to the dredging activities during their passage through the Stockton DWSC to San Francisco Bay. As with adults, NMFS expects the most likely period for them to be present is in the month of December.

All Central Valley steelhead from the San Joaquin River drainage and Calaveras River have the potential to be exposed to the long-term effects of the Corps' maintenance dredging actions and levee stabilization work. The total number of steelhead exposed to adverse effects associated with the altered habitat could range from several hundred to a few thousand individuals, depending on the run size for that year. A small number of steelhead from the Sacramento River drainage could be exposed as well (see below).

Although the San Joaquin River and Stockton DWSC are outside of the ESU limits for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, these fish also may be drawn into the lower San Joaquin River and DWSC along with Central Valley steelhead originating from the Sacramento River drainage. As discussed in the *Status of the Listed Species and Critical Habitat* section, both adults migrating upstream to spawning areas and juvenile outmigrants from the Sacramento River can be drawn into the central and south Delta due to SWP and CVP pumping activities and associated operations such as opening the Delta Cross Channel gates. Most migration for juveniles and adults of all three species occurs in the winter and spring (*i.e.*, from December through May).

For Sacramento River winter-run Chinook salmon, the work window for project activities (June 1 to December 31) should preclude most instances of exposure to all but the earliest migrating adults and juveniles, and then only to those fish that enter into the San Joaquin River system. Early adults are likely to be present in the action area only in December; early juveniles may be present in November and December, especially if significant rainfall events occur to trigger their outmigration behavior.

No adult Central Valley spring-run Chinook salmon are expected to occur in the action area during the period from June 1 through December 31. Yearling fish may appear in the San Joaquin River as early as late October, but are not likely to occur in any substantial numbers until after February when the bulk of juvenile spring-run Chinook salmon begin to enter the Delta.

The duration of exposure for straying adults to the effects of the proposed project likely would be on the order of days. The duration of exposure for downstream juvenile migrants is anticipated to last no longer than 2 weeks, based on data from the Vernalis Adaptive Management Plan mark and recapture experiments on fall-run Chinook salmon smolts.

North American green sturgeon are anticipated to be present in small numbers throughout the action area during the Corps' activities. Although information for the density of green sturgeon presence currently is not available, their continual but infrequent occurrence in sampling studies targeting other fish species indicates that they may be present throughout the year within the mainstem of the San Joaquin River and thus vulnerable to both short-term and long-term adverse effects of the project.

2. Maintenance Dredging Action

The maintenance dredging action will remove accumulated sediments from the bottom of the Stockton DWSC from RM 4 to RM 41 as required to ensure safe passage of maritime vessel traffic. The width of the channel varies from a little over 200 feet to over 600 feet, with the downstream reaches typically being wider than the upstream reaches. Historically, the Corps has removed amounts of sediment ranging up to approximately 850,000 cubic yards from the DWSC annually, but typically removes less than half of that volume. In the project description, the Corps has indicated that they do not anticipate removing more than 500,000 cubic yards in any given dredging cycle. The quantity of material to be removed each working day would not exceed 8,576 cubic yards. In general the adverse effects of dredging on exposed listed salmonids and proposed North American green sturgeon are likely to include the following: (1) behavioral, physiological, or physical changes or impairment in response to resuspension of sediment and contaminants, noise, and continuation or exacerbation of existing adverse conditions, and (2) mortality resulting from entrainment.

a. *Sediment Characteristics*

The Corps has characterized the sediments that will be dredged from the five different reaches from RM 4 through RM 41. The dredge material has low to moderate contamination for metals, based on the analysis of dredge material from each reach. Over the past five dredging cycles, elevated levels of arsenic, cadmium, total chromium, copper, nickel, and zinc have been found in representative core samples from the five different reaches (Corps 2005). In addition, elevated levels of ammonia and turbidity (as measured by NTUs) have been detected in the effluent discharge from the DMP sites. The Corps did not provide data for any organic compounds (*i.e.*, pesticides, solvents, polycyclic aromatics, *etc*.) in its sediment characterizations. Uptake of contaminants may cause acute mortality, but uptake of lower levels may be expected to have a variety of sublethal adverse effects on reproduction, development, growth, and behavior of aquatic organisms (Laws 1993).

The following two sections describe the contaminants found in the sediments tested within the proposed dredging sites that are of sufficiently elevated concentrations to be of concern to NMFS (*i.e.*, copper and ammonia). Of the metals examined, only copper is sufficiently elevated in the sediment to pose a significant risk to migrating salmonids. Another compound that poses a reasonably certain level of risk to migrating salmonids are the ammonia levels in the sediment. The potential for adverse effects from these and other contaminants found in sediments are anticipated to be greater for North American green sturgeon, which is a benthic species and therefore is more likely to have direct dermal content with sediment and contaminants resuspended by the dredge cutterhead; consume benthic invertebrates and therefore more likely to bioaccumulate contaminants in their body; and, likely to have greater exposure to the action because of their longer residence in the action area. The analysis of sediment constituents that were excluded from this narrative are described in full in a technical memorandum to the administrative file.

(1) Copper. Sediment copper concentrations ranged from a minimum of 5.1 mg/kg to a maximum of 67.6 mg/kg. Copper concentrations became progressively more elevated the closer the dredging reach was to the Port of Stockton. The sediment safety guidelines for copper concentrations at which the threshold of adverse effects begins to occur is 31.6 mg/kg - 35.7 mg/kg (Buchman 1999, MacDonald *et al*. 2000). As copper concentrations in the sediment become higher, the equilibrium partitioning between the sediment and the aqueous phases (pore water and overlying water) pulls copper out of the solid sediment phase and into the dissolved phase until equilibrium is achieved. The addition of copper species to the dissolved phase increases the risk factor to exposed salmonids as well as other aquatic species. This process can be exacerbated by sediment resuspension which creates a larger surface area for equilibrium transfer between the solid phase and the aqueous phase.

Pacific salmonids (*Oncorhynchus* spp.) are very susceptible to copper toxicity, having the lowest LC_{50} (*i.e.* the concentration at which 50 percent of the exposed population dies in a given time period, Rand *et al.* 1995) threshold of any group of freshwater fish species tested by the EPA in their Biotic Ligand Model (BLM; EPA 2003) with a Genus Mean Acute Value (GMAV) of 29.11 µg/l of copper concentration in the water. In comparison, fathead minnows (*Pimephales promelas*), the standard EPA test fish for aquatic toxicity tests, have a GMAV of 72.07 µg/l of copper. The BLM standardizes water chemistry parameters such as pH, dissolved organic carbon (DOC), percentage of humic acid, temperature, major cations (Ca^{+2}, Mg^{+2}, Na^{+}, and K^{+}), major anions (SO_4^{-2}, Cl^{-}), dissolved inorganic carbon, and sulfide in calculating the lethal toxicity criteria, thus allowing direct comparisons between species' sensitivities to copper that have been tested in different water qualities. Water hardness has frequently been cited as an ameliorating factor in reducing copper toxicity, perhaps due to the competition between the divalent cations in the carbonate complexes (*i.e.*, $CaCO_3$) and the divalent copper ions for ligand binding sites on the fish's cellular membranes. Marr *et al.* (1999) analyzed the bioavailability and acute toxicity of copper to rainbow trout (*O. mykiss*) in the presence of organic acids and concluded that the low-affinity ligands act in a similar fashion, that the toxicity of copper is determined by the binding affinities of specific DOC components relative to copper-binding affinities of the fish's gill epithelium.

In addition to the elevated risk of mortality to Pacific salmonids from relatively low concentrations of copper, members of this genus of salmonids are also prone to incur substantial sublethal physiological effects from slightly elevated concentrations of copper above natural environmental levels. Hansen *et al.* (2002) exposed rainbow trout to sub-chronic levels of copper in water with nominal water hardness of 100 mg/L (as $CaCO_3$). Growth, whole body copper concentrations, and mortality were measured over an 8 week trial period. Significant mortality occurred in fish exposed to 54.1 µg/l Cu (47.8 percent mortality) and 35.7 µg/l Cu (11.7 percent mortality). Growth and body burden of copper were also dose dependent with a 50 percent depression of growth occurring at 54.0 µg/l, but with significant depressions in growth still occurring at copper doses as low as 14.5 µg/l after the 8 week exposure. In a separate series of studies, Hansen *et al.* (1999a, b) examined the effects of low dose copper exposure to the electrophysiological and histological responses of rainbow trout and Chinook salmon olfactory bulbs, and the two fish species behavioral avoidance response to low dose copper. Chinook salmon were shown to be more sensitive to dissolved copper than rainbow trout and avoided copper levels as low as 0.7 µg/l copper (water hardness of 25 mg/L), while the rainbow trout avoided copper at 1.6 µg/l. Avoidance response was lost in Chinook salmon at a copper concentration above 44 µg/l, while rainbow trout lost their avoidance response at concentrations above 180 µg/l of copper. Long-term acclimation to low dose copper (2 µg/l) for 25 to 30 days prior to exposure diminished all avoidance response in Chinook salmon at any of the levels tested (3.4 to 21.0 µg/l) when the alternative was either the long-term exposure water (1.6 µg/l) or "clean" test water (0 µg/l). In contrast, rainbow trout retained their avoidance of any copper levels higher than the control concentration of 1.6 µg/l. The intensity of avoidance responses were similar to those of naive fish which had not been acclimated to copper beforehand.

Concentrations of copper below the acutely toxic levels needed to elicit mortality or morbidity have been shown to significantly reduce the olfactory response of exposed salmonids. Diminished olfactory sensitivity reduces the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprinting of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen *et al.* 1999b). The electrophysiological responses of Chinook salmon and rainbow trout to concentrations of copper ranging from 25 to 300 µg/l were examined in a subsequent series of experiments. The olfactory bulb electroencephalogram (EEG) responses to the stimulant odor, L-serine (10^{-3} Molar), were initially reduced by all copper test concentrations, and completely eliminated in Chinook salmon exposed to $50 µg/l and in rainbow trout exposed to $200 µg/l within 1 hour of exposure. Following copper exposure, the EEG response recovery to the stimulus odor were slower in fish exposed to higher copper concentrations. Histological examination of Chinook salmon exposed to 25 µg/l copper for 1 and 4 hours indicated a substantial decrease in the number of receptors in the olfactory bulb due to cellular necrosis. Similar receptor declines were seen in rainbow trout at higher copper concentrations during the 1 hour exposure, and were nearly identical after 4 hours of exposure. A more recent olfactory experiment (Baldwin *et al.* 2003) examined the effects of low dose copper exposure on coho salmon (*O. kisutch*) and their neurophysiological response to natural odorants. The inhibitory effects of copper (1.0 to 20.0 µg/l) were dose dependent and were not influenced by water hardness. Declines in sensitivity were apparent within 10 minutes of the initiation of copper exposure and maximal inhibition was reached in 30 minutes. The experimental results from the multiple odorants tested indicated that multiple olfactory pathways are inhibited and that the threshold of sublethal toxicity was only 2.3 to 3.0 µg/l above the dissolved copper background. The results of these experiments indicate that even when copper concentrations are below lethal levels, substantial adverse effects occur to salmonids exposed to these low levels. Reduction in olfactory response is expected to increase the likelihood of morbidity and mortality in exposed fish by impairing their homing ability and consequently migration success, as well as by impairing their ability to detect food and predators.

As the elevated levels of copper in the previously buried sediment horizons are exposed by the proposed dredging activities to the overlying water column, several chemical and biological transformations are anticipated (see Appendix B, Figure 7). Exposure to oxygen will create chemical oxidation/reduction reactions in previously reduced chemical compounds. Some of these reactions are expected to release copper compounds contained in the sediment to the overlying water column by increasing the solubility of the copper metal complexes. These reactions will continue to take place until chemical equilibrium is established between the sediment and the overlying water column. Similarly, biological reactions, particularly those due to microbial actions, are expected to increase the availability of copper in the DWSC. Based on chemical equilibrium data provided by the applicant, dissolved copper levels that are equivalent to the levels of copper shown to reduce growth or impair olfactory responses in laboratory experiments are expected.

In addition to these physiological responses to copper in the water, Sloman *et al.* (2002) found that the adverse effect of copper exposure was also linked to the social interactions of salmonids. Subordinate rainbow trout in experimental systems had elevated accumulations of copper in both their gill and liver tissues, and the level of adverse physiological effects were related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, is presumed to lead to increased copper uptake across the gills due to elevated ion transport rates in chloride cells. Furthermore, excretion rates of copper may also be inhibited, thus increasing the body burden of copper. Sloman *et al.* (2002) concluded that not all individuals within a given population will be affected equally by the presence of waterborne copper, and that the interaction between dominant and subordinate fish will determine, in part, the physiological response to the copper exposure.

The levels of copper in the sediment phase which will be partitioned to the aqueous phase following exposure via dredging and the return of dredging decant waters from the DMP sites indicate that demonstrable adverse effects can occur to salmonids exposed to these conditions. These effects range from alterations of behavior and olfactory response to acute mortality. As previously explained, copper, as well as other compounds sequestered in the sediment, will come into chemical equilibrium with the overlying water column. The changes in oxygen content and pH, as well as the concentration gradient between the sediment and the water are expected to mobilize chemical constituents. Activity by biological processes, such as bio-perturbation or microbial metabolism can further accelerate the mobilization of compounds from these sediment horizons which were previously below the zone of biotic activity into the aquatic environment.

(2) Ammonia. Ammonia is a common aquatic pollutant which enters natural waters with municipal, agricultural, fish-cultural, and industrial wastes. It is also a natural degradation product of nitrogenous organic matter and protein metabolism. Organic materials that fall out of the water column and settle to the bottom are colonized by microbes. These microbes metabolize the organic material, producing ammonia from the metabolism of nitrogenous materials (*i.e.*, proteins). Perturbation of the bottom aerobic and anaerobic layers in the sediments can release significant quantities of the highly soluble ammonia into the overlying water. The Regional Board has indicated that ammonia levels may reach levels as high as 25.5 mg/L in the filtered liquid samples (elutriate) obtained from mixing deionized water with the dredge material samples from the Port of Stockton reach. In an aqueous solution, ammonia assumes both an ionized form (NH_4^+) and an un-ionized form (NH_3). The ratio between the two species of ammonia is pH sensitive. The more acidic (lower pH) the aqueous solution is, the greater the equilibrium equation is shifted towards the formation of NH_4^+, as would be expected of a weak base.

Salmonids are very sensitive to the level of un-ionized ammonia in the aqueous environment. Thurston and Russo (1983) found median acute toxicity levels of NH_3 in rainbow trout to range from 0.16 to 1.1 mg/Liter in 96-hour exposures. The exposed fish ranged from 1-day old fry (<0.1 g) to 4-year-old adults (2.6 kg). Sensitivity to NH_3 decreased as the fish developed from fry to juveniles, and then subsequently increased as fish matured. LC_{50} did not appreciably change in concurrent exposures for 12- and 35-day test by the same authors. Thurston *et al.* (1984) measured chronic toxicity of rainbow trout to several low dose concentrations of ammonia (0.01-0.07 mg/L un-ionized ammonia) over a 5-year period, exposing 3 successive generations of trout to the toxicant. The trout exhibited dose dependent changes in the level of ammonia in their blood, and fish exposed to ammonia concentrations of 0.04 mg/L or higher of un-ionized ammonia exhibited pathological lesions in their gills and kidneys. There were no gross signs of toxicity at any of the test dose exposures, even though the histological examinations indicated abundant sublethal pathologies.

Lesions within the gill tissues create adverse conditions for oxygen exchange in exposed fish. Common types of pathologies observed in chronically exposed trout were “clumping” of gill filaments, separation of epithelial cells from their underlying basement membranes, and micro-aneurisms (Thurston *et al.* 1984). The resulting abnormalities in the gill tissues can be expected to reduce the efficiency of oxygen transfer across the gill epithelial cells, and thus make the fish more susceptible to adverse effects from low DO conditions. In addition, the injured tissues are more susceptible to pathogens and increase the likelihood of morbidity in exposed fish.

Lesions in the renal tissues of the exposed trout included nephrosis, degeneration of renal tubule epithelia, and partial occlusions of the lumen of the renal tubules. These lesions can be expected to impair glomerular blood flow and filtration, and eventually induce renal failure. In an anadromous fish, such as Chinook salmon, steelhead or sturgeon, a properly functioning renal system is imperative for osmotic regulation in its freshwater life stages. The renal system produces the dilute urine necessary to maintain the proper level of hydration. Without the ability to produce dilute urine, the fish will continue to absorb water until the osmotic pressure between the outside aquatic environment is balanced by the internal tissue osmolality.

The ammonia concentrations developed in the elutriate tests are sufficiently elevated to cause acute toxicity to exposed salmonids in the water column. Lower concentrations below the lethal thresholds may cause tissue and cellular damage.

b. *Turbidity and Sediment Resuspension*

The dredging activity will create conditions that will increase local turbidity through the resuspension of sediment. Previous estimates of dredge created turbidity have indicated that dredging will result in an approximately 10 percent increase in total suspended solids downstream of the dredging action (Regional Board 2004), which should not greatly change conditions in the DWSC compared to background turbidity levels.

Suspended sediments can adversely affect salmonids in the area by clogging sensitive gill structures (Nightingale and Simenstad 2001) but are generally confined to turbidity levels in excess of 4,000 mg/L. Based on the best available information, NMFS does not anticipate that turbidity levels associated with the dredging action itself will increase to levels that are directly causing adverse effects to this degree upon exposed salmonids. However, responses of salmonids to elevated levels of suspended sediments often fall into three major categories: physiological effects, behavioral effects, and habitat effects (Bash *et al.* 2001). The severity of the effect is a function of concentration and duration (Newcombe and MacDonald 1991, Newcombe and Jensen 1996) so that low concentrations and long exposure periods are frequently as deleterious as short exposures to high concentrations of suspended sediments. A review by Lloyd (1987) indicated that several behavioral characteristics of salmonids can be altered by even relatively small changes in turbidity (10 to 50 NTUs). Salmonids exposed to slight to moderate increases in turbidity exhibited avoidance, loss of station in the stream, reduced feeding rates and reduced use of overhead cover. Reaction distances of rainbow trout to prey were reduced with increases of turbidity of only 15 NTUs over an ambient level of 4 to 6 NTUs in experimental stream channels (Barret *et al.* 1992). Increased turbidity, used as an indicator of increased suspended sediments, also is correlated with a decline in primary productivity, a decline in the abundance of periphyton, and reductions in the abundance and diversity of invertebrate fauna in the affected area (Lloyd 1987, Newcombe and MacDonald 1991).

Resuspension of contaminated sediments may have adverse effects upon salmonids that encounter the sediment plume, even at low turbidity levels. Lipophilic compounds in the fine organic sediment, such as toxic polyaromatic hydrocarbons (PAHs), can be preferentially absorbed through the lipid membranes of the gill tissue, providing an avenue of exposure to salmonids experiencing the sediment plume (Newcombe and Jensen 1996). Similarly, charged particles such as metals (*e.g.*, copper), may interfere with ion exchange channels on sensitive membrane structures like gills or olfactory rosettes and increases in ammonia from the sediment may create acutely toxic conditions for salmonids in the channel. Overall, the changes in turbidity and suspended sediment associated with this project therefore are expected to adversely affect listed species primarily by low-level, long-term alteration of habitat conditions.

In addition to the effects described above, the suspended sediment can also increase the chemical oxygen demand (COD) within the waters of the DWSC. Data developed for the Port of Stockton West Complex Redevelopment project (Regional Board 2004) indicates that the additional suspended sediment from dredging actions in the Port will increase COD from approximately 0.74 mg/L to 1.8 mg/L of oxygen for the old sediment horizon, 0.5 mg/L to 1.0 mg/L for the composite sediment sample, and 0.08 mg/L to 0.5 mg/L for the new sediment horizon. NMFS will assume that at least for the dredging reaches near the Port of Stockton, the composition of the dredge materials should be similar to those anticipated by the Corps for the DWSC. The addition of this oxygen demand upon the DO in the channel will exacerbate the frequently low DO levels seen in the channel during the periods between September and December when adult steelhead maybe moving upstream through the DWSC near the West Complex. NMFS anticipates that the addition of this extra COD will increase the frequency of DO depressions below the 5 mg/L DO standard in the California Water Quality Control Plan for the Central Valley (Basin Plan), which also is the minimum requirement for salmonids. This is expected to increase the length and frequency of migration delays by Central Valley steelhead into the Calaveras River and San Joaquin River.

Based on the timing of the dredging actions (June 1 through December 31), NMFS expects the majority of the direct impacts created by dredging activity to be experienced by adult Central Valley steelhead migrating upstream to the watersheds of the Calaveras and San Joaquin Rivers and early migrating Sacramento winter-run Chinook salmon juveniles passing into the Central Delta from the Sacramento River system during the later portion of the dredging season. Although some steelhead smolts may be migrating downstream at this time, their numbers are expected to be low compared to the peak of migration in spring and would tend to be associated with rain events or pulse flow operations on the tributaries. Increased flows in the main channel of the San Joaquin River, as a result of pulse flows or precipitation, are expected to ameliorate the negative effects of the dredging action by shortening the duration of migration through the action area and diluting the resuspendend sediments in the water column. Similarly, winter-run Chinook salmon juveniles often exhibit early migrational behavior that is correlated with rainfall events and increased turbidity in the Sacramento River. Passage into the Central Delta and the San Joaquin River system is through one of the interconnecting channels from the Sacramento River (*i.e.*, Georgiana Slough, the Mokelumne River system via the Delta Cross Channel Gates near Walnut Grove, and Three Mile Slough) and by tidal circulation near Chipps Island in the West Delta. The exposure risk to green sturgeon is less clear. It can be anticipated that juvenile and adolescent green sturgeon could be found year-round in the central Delta, particularly in the deeper sections of the DWSC based on sturgeon behavior and their preference for deep holes in river channels.

c. *Entrainment by Dredges*

The hydraulic cutterhead dredge operates by pulling water through the cutterhead assembly, upwards through the intake pipeline, past the hydraulic pump, and down the outflow pipeline to the DMP site. The suction creates a field of influence around the head of the dredge intake pipe. The size of the field of influence surrounding the cutterhead is dependent on the diameter of the pipeline, the power of the pump, and how deep the cutterhead is extended into the sediment layer. The hydraulic dredge that is to be used in this project will have a 16-inch diameter intake pipe that is powered by a 2,000 hp hydraulic suction pump (Corps 2005). According to estimates supplied by the Corps, this will discharge approximately 4.3 to 6.6 cfs from the end of the pipeline. This is equivalent to 2.7 to 4.2 feet per second (ft/sec) flow velocity at the mouth of the cutterhead.

The Corps interactive model (available at: http://el.erdc.usace.army.mil/dots/doer/flowfields) calculates that the flow fields surrounding a cutterhead with a hemisphere above the sediment surface (half of the cutterhead diameter) will have a velocity of 38 cm/sec at 0.5 meters from the intake with a given suction pipe velocity of 15 ft/sec (approximately 4 times greater than anticipated for this project). At about 1.5 meters from the cutterhead, flow velocities are reduced to 4.2 cm/sec. If the average size steelhead smolt is approximately 150 mm, then the flow velocity, even within 0.5 meters of the cutterhead, are below the burst swimming speed of 10 body lengths (BL)/sec for salmonids. Likewise, a winter-run Chinook salmon smolt with an average length of 85 mm would still have sufficient burst speed capacity to overcome the intake velocity of the dredge. Modeling a quarter hemisphere flow field for a deeper entrenched cutterhead, the Corps model calculates that flow velocities will be 76 cm/sec at 0.5 meters and 8.4 cm/sec at 1.5 meters. The velocities within 0.5 meters of the cutterhead are still below the critical 10 BL/sec burst swimming speed for steelhead smolts but are approaching the burst speed limits for smaller salmonids (Webb 1995). Therefore, it is unlikely that either a steelhead smolt or a winter-run Chinook salmon smolt that detects the presence of the cutterhead would be unable to escape its field of influence, unless its swimming ability was in some way compromised. Furthermore, most dredging will take place in water deeper than 20 feet. It is not anticipated that steelhead or Chinook salmon smolts would be at this depth during their seaward migration, thus further insulating them from the effects of the flow fields surrounding the cutterhead. Adult salmonids that may encounter the hydraulic dredge would likewise be able to avoid and escape entrainment due to their greater swimming speed.

Notwithstanding this set of information, the Corps modeling indicates that smaller salmonids may be at risk as the flow velocities may exceed the burst swimming capabilities of the fish. Earlier Corps studies of juvenile salmonid entrainment in the lower Fraser River, British Columbia, Canada indicated that dredging in confined waters, such as narrow constricted channels where fish occupied the entire channel, could result in substantial entrainment rates of salmon (Dutta and Sookachoff (1975) as cited in Reine and Clark 1998). Estimates of entrainment rates by hydraulic dredging ranged from 0.00004 to 0.4 percent of the total out-migration of fry and smolts (Arsenault (1981) in Reine and Clark 1998). The Corps report (Reine and Clark 1998) estimated that for chum salmon (*O. keta*), entrainment rates for hydraulic pipeline dredging were 0.008 fish/cubic yard of dredged material. This would be equivalent to approximately 4,000 salmon juveniles entrained for the entire 500,000 cubic yards of dredged material proposed, if salmon fry and juveniles were present during the dredging action. The Corps report also concluded that for upland confined dredging material disposal, as is proposed for this project, entrainment mortality would be 100 percent.

Juvenile and adolescent green sturgeon also may be at an elevated risk of entrainment from the hydraulic dredge. Based on data from the same paper for salmon entrainment (Reine and Clark 1998), sturgeon juveniles were entrained at high rates on the Columbia River from localized areas known to have aggregations of sturgeon (sturgeon holes). The behavior of sturgeon apparently places them at risk to dredging actions due to their preference for deep channels and holes (*i.e.*, the DWSC) and their reluctance to move away from those areas even when disturbed. Since NMFS assumes that the green sturgeon will occupy the Delta habitat year-round during their juvenile and sub-adult phases, exposure to entrainment will occur throughout the entire dredging window for the Stockton DWSC.

In addition to salmonids and green sturgeon, other organisms would be entrained by the hydraulic suction dredge, particularly small demersal fish and benthic invertebrates. The Corps report (Reine and Clark 1998) estimated that the mean entrainment rate of a typical benthic invertebrate, represented by the grass shrimp, when the cutterhead was positioned at or near the bottom was 0.69 shrimp/cubic yard but rose sharply to 3.4 shrimp/cubic yard when the cutterhead was raised above the substrate to clean the pipeline and cutterhead assembly. Likewise, benthic infauna, such as clams, would be entrained by the suction dredge in rates equivalent to their density on the channel bottom, as they have no ability to escape. The loss of benthic food resources, such as amphipods or isopods, could reduce fish growth rates and increase the energy expended searching for food, depending on the density of the animal assemblages on the channel bottom. This would be more likely to occur to sturgeon, which are specialized benthic feeders, but also could affect juvenile salmon and steelhead. NMFS believes that small invertebrates such as annelids, crustaceans (amphipods, isopods), and other benthic fauna would be unable to escape the suction of the hydraulic dredge and be lost to the system. Also, many benthic invertebrates have pelagic, surface-oriented larvae; therefore the loss of these benthic invertebrates may reduce the abundance of localized zooplankton populations in the upper regions of the water column where juvenile salmonids migrate through the DWSC. The timing of the dredging cycle (summer-fall) may preclude forage base replacement by recruitment from surrounding populations prior to the following winter and spring migration period of juvenile steelhead through the dredging action area (Nightingale and Simenstad 2001).

d. *Acoustic Impacts of Dredging*

High levels of underwater acoustic noises have been shown to have adverse impacts upon fish within close proximity of the noise source. The Corps has indicated that the dredging action will operate continuously for several days while dredging the project area. Even though the suction dredge may not be in constant operation (estimated at 8 to 10 hours daily), other activities aboard the dredge will continue on a 24-hour cycle such as cleaning the cutterhead, repositioning the dredge itself, and conducting maintenance work. Within the upstream reaches of the proposed dredging action area, the width of the DWSC ranges from less than 80 meters wide (225 to 250 feet) to approximately 150 meters wide (500 feet) and 36 feet deep. This represents a fairly confined volume of water for sound propagation. Further downstream, the channel widens and the width of the river increases substantially to several thousand feet.

In general, underwater sound dissipates with distance from the source. In an ideal model, the intensity of the sound energy produced at the point source spreads itself out over a spherical surface so that by conservation of energy, the total energy spread over the spherical surface at any given distance from the point source is equal to the energy at the point source. In the real world, this simple model is complicated by the water surface and channel bottom reflecting sound energy back into the water column and the formation of constructive and destructive sound wave interference. Studies conducted by the Corps (Clarke *et al.* 2002) measured sounds produced by different dredging methods, including hydraulic cutterhead dredges. Clarke *et al.* (2002) measured sound energy in the 70 to 1,000 Hz range from the dredging activity. The sound energy peaked at a level of 100 to 110 dB (presumably at a reference pressure of 1µPascal (re:1µPa), although it was not cited in the report text) at an unspecified distance from the dredge. Assuming that the measurements for the cutterhead hydraulic dredge were made at similar distances as the other dredge methods, the closest distance would be 40 meters (131 feet) (based on the hopper dredge measurements). Based on this distance, the calculated point source level of sound energy is equal to 153 dB. Conversely, based on the finding that the sounds emitted by the hydraulic dredge were barely detectable at 500 meters, as Clarke *et al.* (2002) state, then the point source noise energy is equal to 125 dB assuming that the background noise is between 50 and 60 dB. Transient noise associated with machinery and deck activities may be substantially above these energy levels, as indicated by the bucket dredge data. Sounds created from topside activities can be easily and efficiently transferred through the barge hull to the surrounding water column, particularly from metal to metal contact.

Recent studies by Scholik and Yan (2002) studied the effects of boat engine noise on the auditory sensitivity of the fathead minnow. The majority of noise generated from the motor is derived from the cavitation of the propeller as it spins in the water. Fish were exposed to a recording of the noise generated by a 55 hp outboard motor over a period of 2 hours. The noise level was adjusted to 142 dB (re:1µPa), which was equivalent to the noise levels measured at 50 meters from a 70 hp outboard motor. The experimental fish suffered a drop in hearing sensitivity over the range of frequencies normally associated with their hearing capabilities. These responses were measured using electrophysiological responses of their auditory nerves under general anesthesia. Studies by McCauley *et al.* (2003) on the marine pink snapper, indicated that high-energy noise sources (approximately 180 dB (re:1µPa) maximum) can damage the inner ears of aquatic vertebrates by ablating the sensory hairs on their inner ear epithelial tissue as revealed by electron microscopy. Damage remained apparent in fish held up to 58 days after exposure to the intense sound. Although little data from studies utilizing salmonids is available, NMFS assumes that some level of adverse impacts to salmonids can be inferred from the above results. Exposures of these other fish species can serve as surrogates for salmonids. Adverse effects were measured in these surrogates following as little as 2 hours of exposure to 142 dB (re:1µPa) sound energy.

The loss of hearing sensitivity may adversely affect a salmonid's ability to orient itself (*i.e.,* due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Fish also may exhibit noise-induced avoidance behavior that causes them to move into less-suitable habitat or avoid passing the source of the noise. In the Corps' project, this may result in salmonids fleeing the dredging associated noises and delaying passage around the dredge until the noise abates. Likewise, chronic noise exposure can reduce their ability to detect piscine predators either by reducing the sensitivity of the auditory response in the exposed salmonid or masking the noise of an approaching predator. Disruption of the exposed salmonid's ability to maintain position or swim with the school will enhance its potential as a target for predators. Unusual behavior or swimming characteristics single out an individual fish and allow a predator to focus its attack upon that fish more effectively.

e. *Bathymetry Changes.*

NMFS anticipates that dredging especially in the reaches from Turner Cut upstream to the Port of Stockton, will increase channel volumes and hence water residency times compared to undredged conditions. Under current conditions, the residence time for water in the DWSC to travel from Channel Point to Turner Cut (approximately 7 miles) is inversely proportional to flow in the channel. As flow decreases, the residence time for water traveling between Channel Point and Turner Cut increases. This relationship is expected to continue. Lee and Jones-Lee (2005) estimated that at a flow of 250 cfs, a unit of water would take approximately 32 days to travel the 7 miles downstream to Turner Cut. At a flow of 1000 cfs, this travel time would be reduced to 8 days. As the volume of the channel increases, the residency time increases, provided flows entering the channel at Channel Point remain the same. As residency time increases for water in the DWSC, NMFS anticipates an inverse decline in water quality, particularly DO, which is an existing problem in this area. Although the installation of aerators is planned for this area (NMFS 2005b), continued depressions of the DO level below 5 mg/L oxygen (*i.e.,* the amount required by salmonids) are expected during the primary migratory season of listed salmonids (November through May). When these low DO levels occur, they are expected to form a physiological barrier and delay migration by salmonids.

f. *Repeated Disturbance.*

The long-term effects of the dredging action on sediment characteristics and benthic communities may be cyclical in nature. Over the course of the 10-year maintenance dredging cycles, new sediments will be deposited and some benthic community recolonization may occur in the infrequently dredged reaches. In the frequently dredged reaches, continual bottom disturbances will reduce species richness and community complexity, and perhaps decrease organism density. The main effects that are anticipated to affect listed salmonids and green sturgeon are possible spikes in contaminant levels and DO sags due to resuspension of chemicals and organic materials, and disturbance of benthic invertebrate communities, which may affect food availability.

g. Dredge Material Disposal

The DMP sites selected by the Corps for disposal of the dredge material consist of several sedimentation basins located along the length of the DWSC. Most of these DMP sites have been in use for several years, and contaminants from several different dredging cycles have had the opportunity to leach downward through the sediment and into the underlying soils. NMFS is concerned that the capacity for the native soil to capture contaminants and hold them in place may have been saturated, thus allowing the leachate constituents to migrate with the island's groundwater into the agricultural drainage canals that discharge into the San Joaquin River. Leachate is defined as interphase transfer of contaminants from dredged material solids to the pore water surrounding the solids and the subsequent transport of these contaminants by pore water seepage (Schroeder 2000).

Contaminants in the aqueous phase are convected with the pore water in the dredge material as leachate. As leachate is transported through porous media, redistribution of the contaminants between the advected pore water (leachate) and the new solids encountered (the surrounding porous media) occurs, and a new equilibrium between the leachate and solids is reached (Schroeder 2000). Within the overlying dredge material, various chemical reactions influence the potential movement of contaminants. Dredge material placed by hydraulic dredging rarely adds sufficient oxygen to overcome the sediment oxygen demand of polluted sediments. Therefore, dredged material is typically anaerobic except for a thin surface crust that develops as the DMP site is dewatered by evaporation and decanting. However, as this crust thickens while drying out, materials in the dredged material become oxidized. If iron or manganese compounds are present in the dredged material, then their oxidation will produce hydrogen ions. Likewise if sulfides are present in the dredged material, oxidation will produce sulfates. The production of these oxidation reactions will increase acidity. Acidic conditions favor the creation of free metal ions, but also the creation of insoluble hydrous oxides that tend to reduce the concentration of metal ions in solution by adsorbing them. These two reactions work in opposition to each other.

If current soil conditions on the Roberts Island DMP site are indicative of conditions in the other sites, then the soils are acidic (pH ranges from 5.2 to 5.8). Attempts to neutralize the acidity by the application of lime were only temporarily successful, as the acidic conditions returned in the months following the applications (Regional Board 2004). Testing detected arsenic, barium, copper, lead, mercury, and nickel at levels that have the potential to impact groundwater.

The DMP sites will have decant water discharges to the San Joaquin River as indicated in Table 2. In general, the decant water plume is expected to contain elevated levels of heavy metals, ammonia, organic compounds, and fine sediments (see *Sediment Characteristics* section above, for further discussion on the impacts to listed species). Data supplied by the Corps for sediment constituents indicates that the receiving waters of the Delta may be impacted by the following metals: arsenic, cadmium, chromium (total), copper, nickel, and potentially zinc. The portion of the San Joaquin River that accepts the effluent returns from the DMP sites is tidally influenced. The extended residency time of the water within the channel may confound the calculations for dilution rates, resulting in higher loadings than theoretically calculated. At low flow rates, the residency time for water in the DWSC ranges from a few days to several weeks. Material discharged into the channel with the decant water may reside in the channel for several weeks, moving back and forth in the channel several times, before being flushed from the system, providing it remains in a soluble state. This back and forth movement may cause contaminants to accumulate in the sediment surrounding the outfall as material is flocculated or precipitated in the ambient river water. After the cessation of decant water discharge, the elevated sediment content of pollutants may cause elevated contaminant concentrations in the surrounding water column through equilibrium partitioning. Furthermore, the discharges are expected to occur for some time following the dredging operation due to the water content of the dredge material and local precipitation on the DMP sites following the end of the dredging season. This extended decant period is likely to coincide with listed juvenile Chinook salmon and steelhead migrating downstream during the wet season (January through May).

The decant water also has a strong potential to increase the turbidity surrounding the point of discharge from the DMP site. The slurry that is initially deposited in the DMP site is highly turbid and has a high suspended sediment load. If the DMP site is designed correctly, the decant water is trained through a series of weirs to extend the settling time. This allows the suspended particles to fall out of solution prior to the decant water being discharged. If it is not designed properly or is undersized, the decant water may not have sufficient settling time to allow material to fall out of solution or it allows water to "short circuit" and arrive at the discharge weir too quickly. As previously mentioned, even slight to moderate increases in turbidity can have adverse effects upon exposed salmonids. The effects upon green sturgeon are unknown at this time, but loss or contamination of invertebrate forage bases would be considered a localized adverse effect to sturgeon as would be exposure to contaminated sediment horizons.

2. <u>Bank Stabilization</u>

The Corps has indicated that bank stabilization work will take place between June 15 and November 30 of each year during the term of this biological opinion (*i.e.*, from 2006 through 2015). The Corps will conduct bank stabilization work only within 1,000 feet of the centerline of the Stockton DWSC and only in areas where rock riprap has been placed previously as described in the 1980 EIS (Corps 2005) for the deepening of the Stockton DWSC from 30 to 35 feet. In areas where there is still evidence of rock riprapping, replenishment of eroded surfaces will utilize suitably sized rocks (12 to 18 inches in diameter) placed mechanically; either by land based cranes and dump trucks or barge mounted cranes. The Corps has indicated that all work will be done at low tide to minimize the placement of rock substrate below the surface of the water. Rock replenishment would then proceed upwards to the crest of the levee, with new material being placed between the ordinary high water mark and mean low water mark. The Corps has stated that they will grade the surface if necessary with a dragline to create a uniform surface, free of protruding stones and having a minimum amount of voids as practicable. In areas where the existence of rock is no longer evident, the Corps has indicated that they will remove any vegetation that has become established or LWD that has accumulated in the area to be stabilized. Geotextile filter fabric or similar underlying material will be placed to provide a stable basement layer for the overlying rock riprap. The rock armoring material will then be placed as previously described.

Bank stabilization work conducted towards the end of the construction season (*i.e.*, during October and November) has the potential to directly affect listed salmonids. Both Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon juveniles have the potential to be within the western Delta during this period, particularly if early rains initiate downstream migrations in the Sacramento River basin. Trawl data from both CDFG and USFWS (Brandes *et al.* 2000; CDFG 2001, 2004a, b) have indicated that fish belonging to both of these ESUs are caught sporadically in the lower Sacramento River trawls starting as early as October but increase in numbers by late November and early December. Likewise data from the CVP and SWP fish salvage operations indicate recovery of spring- and winter-run Chinook salmon size fish starting in late November through mid-December. Steelhead smolts may also potentially start migrating through the Delta at this same time as water temperatures cool and early rains provide increased flow in their natal tributaries.

Work on the levees will create disturbances in the nearshore aquatic environment, particularly by increasing suspended sediment loads in the shallow water along the levee bank. Encrusting soils and other materials displaced by the new rock placement are expected to be initially washed into the surrounding waters by river and tidal actions, creating a zone of increased turbidity near the stabilized levee section. New armored levee banks will be devoid of epibenthic organisms until they are colonized by new organism recruitment. In addition, the interstices of the rock riprap create habitat for ambush predators such as largemouth bass and sunfish, which prey upon migrating salmonids utilizing the nearshore environment. The long-term reduction in habitat quality is expected to last from one to several years depending upon the rate at which new vegetation and sediment fills in the barren rock surface and creates a more hospitable substrate. Through this process, the action will continually contribute to the degraded quality of fish habitat in the DWSC and San Joaquin River even though the Corps indicates that bank stabilization will occur only at sites that have been riprapped previously.

Work on the levees may also reduce riparian habitat at the action site. This would be particularly likely in reaches where the rock armoring has nearly or completely degraded and riparian vegetation has regrown on the levee bank. Although the Corps has indicated in their project description that they would replace riparian vegetation removed for levee stabilization at a 3 to 1 ratio, the loss of riparian habitat and any shading of the nearshore environment would continue for several seasons before the remediation planting could be considered to have replaced the value of the removed vegetation. This loss of any high value habitat would diminish the already compromised nearshore habitat in the Delta, and thus create adverse conditions for emigrating juvenile salmonids. Green sturgeon, which prefer deeper habitat, would be less affected.

3. <u>Interrelated and Interdependent Actions</u>

At the current volume of shipping traffic, approximately 150 to 250 ships per year transit the Stockton DWSC to call on the Port of Stockton (an average of 0.4 to 0.7 vessels per day). This number is expected to increase by approximately 130 vessels per year after new berths become available as a result of the Port's West Complex Redevelopment project, which will increase the daily average of vessels calling on the Port to 0.9 to 1.2 vessels per day. The effects of the increase in shipping on listed salmonids have been analyzed as part of the interrelated and interdependent actions associated with the Port of Stockton West Complex Dredging project; NMFS completed consultation on this project on July 19, 2005 (NMFS 2005b). Because maintaining the current volume of shipping for the next 10 years is interrelated and interdependent to the maintenance dredging and levee stabilization of the Stockton DWSC as proposed in the present project, NMFS will analyze the effects of the current volume of shipping on listed salmonids and proposed North American green sturgeon here.

The DWSC extends downstream for 37 river miles to the City of Antioch in Contra Costa County, where the dredged ship channel leaves the main channel of the San Joaquin River at RM 4 and follows New York Slough to its mouth on the Sacramento River near Pittsburgh, California. The DWSC is maintained at -35 feet MLLW by the Corps along its entire length. Dredged channel widths will vary from between 400 to 600 feet in the lower reaches of the DWSC near Antioch to only 225 feet in the middle reaches of the DWSC near Empire Tract and Rindge Tract. According to the NOAA navigation charts for the Delta, most of the channel averages 225 to 250 feet in width through the Delta. On either side of the dredged channel, the average depth of the San Joaquin River is generally less than 10 feet deep, according to NOAA charts for the region (NOAA Chart 18661). This is particularly true for reaches closer to the Port. These shallow water flats may extend for several hundred feet to either side of the dredged channel. A general river width for the San Joaquin River is approximately 600 feet in the reach between the Port and Prisoners Point. Westward of Prisoners Point, the channel widens between the levee banks to over 1000 feet in most reaches, with shallow water conditions on either side of the dredged channel.

The anticipated adverse effects associated with shipping that may impact listed salmonids and proposed North American green sturgeon include the following: increased turbulence, waves, shear forces, and pressure; propeller entrainment; increased sediment resuspension resulting in turbidity and contaminant exposure; increased pollution due to spills and discharges; introduction of non-native invasive species from ballast waters; and increased underwater acoustic noise from shipping sources. These topics will be analyzed in the following sections.

a. *Shipping Related Changes in Channel Hydrodynamics*

The passage of a ship hull through the water creates a series of complex pressure fields surrounding the hull. Factors such as hull shape, vessel speed, channel geometry, and hull displacement all contribute to the behavior of water as it flows around the hull. The forward movement of the hull displaces water both forward and laterally. The wake produced by a ship's passage produces both a diverging surface wave that originates at the bow of the ship and spreads at an angle to the sailing line, and a transverse wake that is propagated in the sailing direction but is perpendicular to the sailing line (Seelig 2002). Smaller recreational motorboats have a greater proportion of diverging wakes than larger commercial ships. Conversely, large commercial ships have a greater transverse wake component than recreational boats do. The maximum wave heights along the sailing line occur where the transverse waves intersect the diverging waves along a cusp locus line. This point varies with ship speed and hull shape. In addition to these effects, vessels operated in confined channels with minimal under keel clearance are subjected to additional forces. The passage of a large hull displaces a large volume of water away from the sailing line of the ship. As the ship passes a given point on the nearby channel bank, the water forced away from the hull's passage surges back towards the sailing line of the ship to "fill in" the void left by the hull's passage. This creates "drawdown" of the water level along the bank, followed by the sharp jump in the water level created by the following transverse wave front. These effects are accentuated by increased ship speeds, shallow channel depths, shallow-water berms along the channel edge and the proximity to the sailing line of the vessel.

The velocity of water flow along the surface of the hull responds much like air flowing over a wing. As the hull passes through the water, the velocity along the surface of the hull accelerates from the bow towards the stern according to Bernoulli's Law compared to water further away from the hull itself. Likewise, in the small under keel clearance typically seen in the DWSC with large draft vessels (24 to 35 foot draft), the speed of water under the hull accelerates towards the stern. According to Bernoulli's Law, this results in a drop of ambient hydrostatic pressure resulting in the phenomena called "stern squat". The stern is actually pulled down towards the bottom from the resulting low pressure field between the hull bottom and the channel substrate.

The jet of water produced by the propeller's thrust also creates a turbulent wake field behind the ship. This turbulent body of water persists for several minutes after the passage of the ship, and aerial photos have indicated that this feature can exist for several miles behind a passing ship depending on speed and water conditions. The field of effects for hull generated turbulence and other hydrodynamic forces extend to at least to the beam of the ship, and based on research done by the Corps for the Upper Mississippi River studies, may extend at least another 25 percent of the ship's beam away from the sailing line (Maynord 2000a, c). Therefore, the wider the hull, the greater the dimensions of the body of water affected by its passage.

Shear Forces: The creation of the large pressure fields surrounding the passage of the ship's hull and their resulting velocity flows create shear forces along the different velocity gradients. These physical forces create hydrodynamic conditions in the DWSC that can result in adverse conditions for listed salmonids, as well as for the aquatic biota that make up their forage base. The passage of large barge tows on the upper Mississippi created substantial shear forces around the barge hulls and the tug pushing them. As the barge hull moved forward in the water, a boundary layer sets up along the sides of the hull where velocities are greatly reduced. At the hull surface, velocity is at or near zero due to hull friction. Shear forces are greatest at this point. As the distance from the hull increases, the water velocity in the boundary layer increases and the shear forces decline to near zero. Since the boundary layer thickness grows with distance from the point of initiation (bow), the amount of flow in the boundary layer increases with distance from the initiation point. The flow in the boundary layer is turbulent except for a short distance near the bow where flow is generally laminar. Turbulent flow along the hull is characterized by eddies having sizes ranging from minute to about the size of the boundary layer thickness (Maynord 2000b). Shear forces along the hull increase with vessel speed or in the reduction of under keel clearance.

Turbidity and Resuspended Sediments: Studies on barge tows in the Mississippi River indicated that flow fields created around the hulls of the barge tow were sufficient to cause increases in turbidity through bottom disturbances resulting from shear forces on the bottom sediment (Corps 2004). Drag created by the passage of the hull through the water creates turbulent flow fields adjacent to the skin of the hull, which continue to be propagated astern of the ship. Additional turbulence is created between the different layers of water adjacent to the hull. Vessels with large cross sections, such as the commercial vessels calling on the Port, set up these fields of turbulent flow within confined ship channels due to their interactions with the channel bottom and the channel edges. The effects increase in proportion to the ratio of the ship's cross-sectional area (SA) to the channel cross sectional area (CA). The greater the SA/CA, the more pronounced the turbulent effects of the ship's passage are on the sediment of the channel's bottom.

In addition, the propeller jet that is generated by the propeller wash creates a turbulent flow field behind the ship that persists for many minutes. When the propeller is within close proximity to the channel bottom, it "plows" the bottom with the propeller created vortex of water flowing off of the propeller blades. The sediment is captured by the flow fields in the jet and is drawn up into the water column. The depth to which the sediment is disturbed is a function of the distance between the propeller tips and the bottom, the velocity of the water as it exits the propeller disc, and the characteristics of the bottom sediment. The closer the propeller tips are to the bottom or the higher the flow velocities are in the propeller jet, the larger the diameter of sediment on the channel bottom that can be dislodged and carried up into suspension (Hamill *et al*. 1999). Fine detritus, such as seen in the upper DWSC near the Port are easily resuspended by the passage of the ships within the DWSC. This resuspension of bottom detritus and sediments can be accentuated by confining structures such as sheetpile walls or rock quays. Recent studies have indicated that propeller washes that are directed at confining structures like levee banks or dock structures or in tight quarters requiring extensive maneuvering accelerate erosion of the bottom substrate (Hamill *et al*. 1999).

This characteristic of ship passage resuspending bottom sediments exacerbates the exposure of contaminated sediments to salmonids within the DWSC. Any contaminant present in the exposed sediment horizon will be continually injected into the overlying water column, as much as once per day, where it can undergo both chemical and biological transformations. If the settling rate of fine detritus is slower than the frequency of ship passage through the DWSC, then the fine detritus may remain in suspension continuously due to the frequent passage of large ships. The greater exposure time to aerobic conditions will allow greater proportions of reduced compounds in the fine detritus to become oxidized, with the potential of becoming more biologically available to exposed organisms. Biological transformations, such as the methylation of mercury, may occur more readily as compounds are redistributed from hypoxic or anoxic horizons to aerobic conditions with their associated fauna and flora. The fine detritus also becomes a food source for any filter or detrital feeder within the larger DWSC area due to river and tidal currents. This will expose a greater proportion of the DWSC's fauna to the contaminated sediments in the Port's domain.

This continual supply of organic and reduced material will also accelerate the consumption of oxygen from the overlying water column. First, increasing the frequency of availability of organic substrates to the process of microbial decomposition in the overlying aerobic water will consume additional DO from the water column. Secondly, reduced compounds that are oxidized in the aerobic portion of the water column reduce the available DO in the water column. These conditions are expected to continue contributing to recurring low DO levels at the Port of Stockton.

b. *Pollution from Shipping*

Shipping activities have an inherent risk of creating additional sources of water pollution in port waterways. Among the more prevalent sources of pollution from shipping activities are the return waters from engine cooling, fuel leaks and spills, discharge of wash waters from decks and superstructures, and contaminants in discharged bilge waters.

The discharge of cooling waters back into the surrounding waters creates an avenue for the introduction of contaminants from the cooling circuit into surface waters. Bad seals and gaskets within the cooling circuit allow lubricants, fuel, and combustion by-products from the propulsion unit to enter the coolant water stream. Most of the petroleum products that end up as contaminants in the coolant stream are known toxicants to aquatic life. In addition to leaks within the coolant circuit, corrosion and rust of the piping used within the cooling circuit can introduce heavy metals into the water stream. Salt water is highly corrosive and eventually will attack the metal fittings and piping within the circuit, even those which are "sealed" to inhibit this corrosion. This slow degradation of exposed metal surfaces releases metal into the coolant water.

Fuel leaks occur frequently from shipping activities, although most are minor in size. These leaks are often the result of damaged fuel line connections, small punctures in fuel tanks, and sloppy fueling procedures. When these spills occur, they are often discharged into surrounding waters via two different routes; from overflow water used in washing down decks and superstructures or by discharging bilge waters while in port. Materials spilled on the topsides of a ship's decks are subject to both rain and the routine washing of the decks with hoses. Both events will carry any deposited fuel or petroleum products overboard through the deck scuppers into the surrounding waters. Materials that leak out from the fuel tanks are frequently deposited in the bilge, where they contaminate the water that gathers there. When this water is discharged from the ship, it carries with it the contaminant load.

c. *Non-native Invasive Species*

The San Francisco Bay estuary has one of the highest rates of invasion by non-native species of any water body on earth (Cohen 1997, Cohen and Moyle 2004). Currently the estuary is host to over 200 different NIS. In some areas of the estuary these NIS account for 40 to 100 percent of the common species encountered during sampling. A major pathway responsible for the introduction of NIS organisms into California waters is the transport of organisms in the ballast waters of ships (Cohen 1997).

The Port of Stockton has indicated that approximately 20 to 25 percent of the ships calling on the Port have discharged ballast water totaling approximately three million gallons per year (Jones and Stokes 2004b). Current regulations require discharges to occur outside of the 200 mile exclusive economic zone in open ocean waters for vessels originating outside the Pacific Coast of North America (Pacific Coast Region). Vessels whose port of origin is within the Pacific Coast Region are to discharge ballast water in near coastal waters (more than 50 nm from land and greater than 200 meters deep) prior to entering California ports. However, at sea exchange of ballast water does not guarantee that all organisms are exterminated within the ballast tanks. Furthermore, the regulations do not have any methodology to guarantee that discharges have occurred as recorded in the ship's documents and that any discharges occurring in port are free of NIS.

d. *Propeller Entrainment*

The presence of ship traffic in the Stockton DWSC results in listed salmonids and North American green sturgeon encountering the propellers of ships. Although the exact number of fish entrained into a propeller's zone of influence is impossible to determine, certain assumptions and modeling of the propeller entrainment zone can be made to give ranges for the numbers of affected fish. In order to make a simple assessment of the number of salmonids subject to propeller entrainment, NMFS determined the length of the route transited by ships in the San Joaquin River DWSC, the range of ship propeller sizes and pitches, vessel speeds and engine characteristics of commercial vessels commonly seen on ships calling on the Port of Stockton, and then applied the recorded density of Chinook salmon in the Delta from published data provided by the FWS to characterize the salmonid entrainment numbers for vessel traffic within the DWSC.

Ships calling on the Port of Stockton have a maximum size limit reflected by the Panamax constraints (Length overall: 965 feet [294 meters]; Beam [width] 106 feet [32.3 meters] and Draft 39.5 feet [12 meters]) and according to the Port's documents have an average speed of 8 to 10 miles per hour (mph) while transiting the DWSC from Pittsburgh to Stockton (Jones and Stokes 2004b). The diameter of a propeller (d) is related to the maximum draft (D) of the ship it propels. Typically d/D is less than 0.65 for bulk carriers and 0.74 for container ships. The largest propellers currently manufactured rarely exceed 10 meters in diameter due to strength and power limitations (Man B&W 2004). Therefore, for a ship with a 35 foot draft, the maximum propeller size would be approximately 22.5 feet in diameter or roughly 7 meters. NMFS used 3 different propeller sizes (4, 5, and 6 meters in diameter) in this assessment. These three propeller diameters span the middle range of expected propeller diameters. They would correspond to ships with drafts from 6.6 meters (21.7 feet) to approximately 10 meters (33 feet). Propeller pitch ratios are the ratio between the distance a fixed point on the propeller tip would move forward in one revolution of the propeller in a solid medium without any slippage and the diameter of the circle swept by the propeller wheel. Typical pitch ratios range between 0.5 and 1.5 for most propellers. Above and below these ratios, the efficiency of the propeller is very low. Power curves for several types of propellers (Man B&W 2004) show typical operating speeds of between 100 to 250 rpm for the propeller. For fixed pitch propellers with a given diameter, speed is determined by the speed of the propeller shaft. Higher revolutions of the propeller shaft will increase the speed of the ship through the water. Variable pitch propellers can alter the pitch ratio of the propeller while underway, thus increasing speed while maintaining the same shaft revolutions. NMFS assigned 2 different engine speeds to the entrainment model: 150 and 200 rpm's. Without specific data for individual ship speed with the given variables of hull efficiency and propeller efficiency, NMFS arbitrarily assigned hull speeds of 5 mph to the 150 rpm shaft speed, and 8 mph to the 200 rpm shaft speed to calculate the volume of water entrained by the different propeller sizes and pitches. NMFS designed a three (propeller diameter) by three (pitch ratio) by two (ship speed) matrix to analyze salmonid entrainment.

NMFS calculated the volume of water that is swept through the propeller disc during three legs of the transit distance between the Port of Pittsburg and the Port of Stockton; the Port of Pittsburg (RM 0) to Blind Point, Blind Point to channel marker "47" at the mouth of the South Fork of the Mokelumne River, and channel marker "47" to the Port of Stockton (RM 41). These volumes were then multiplied by the different Chinook salmon densities, as measured by the FWS during their monitoring efforts at Chipps Island, Jersey Point, and Prisoners Point (FWS 2003b; Cadrett 2005). The products of these calculations were then adjusted for slippage, a measurement of propeller performance (Man B&W 2004) and the projected rate of mortality for smolting salmonids between 85 and 250 mm in length passing through the blades of a propeller or turbine (Gloss and Wahl 1983; Holland 1986; Giorgi et al. 1988; Cada 1990; Dubois and Gloss 1993; Killgore et al. 2001; Gutreuter et al. 2003) to derive the number of salmon mortalities for one year's volume of ship traffic in the DWSC. NMFS used a value of 80 percent efficiency for propellers to determine slippage and a mortality value of 40 percent for fish that encountered the propeller.

Dubois and Gloss (1993) reported immediate turbine induced mortalities of 66 percent for 85 mm long threadfin shad, 16 percent for striped bass 67 to 83 mm in length and 39 percent for striped bass 136 mm in length immediately after passage through the blades of a turbine. After 24 hours, mortalities for the striped bass increased to approximately 60 to 70 percent for both size classes, indicating a significant delayed mortality effect on these fish. Gloss and Wahl (1983) reported similar results for salmonids with mortality ranging from 15 percent for salmonids 85 mm in length to over 70 percent for salmonids 280 mm in length. In this study mortality occurred quickly (75 percent of the mortality was considered instantaneous) and did not appear to have a latency period like the striped bass study. Like the previous study though, increasing length increased the risk of mortality from propeller strikes for entrained fish.

In addition to physical contact with the blades of the propeller, pressure changes and cavitation associated with the propeller also can cause mortality. Cada (1990) reviewed studies of turbine related mortality on fish and found that while pressurization and decompression from the propeller's actions may cause mortality, it is generally low, while that of the propeller's cavitation may cause upwards of 50 percent mortality in juvenile salmonids exposed to the explosive collapse of the vapor bubbles. The zone of cavitation is small for turbine blades, but is considerably larger for ship propellers, thus presenting a greater opportunity for exposure. Based on the above examples, NMFS believes that 40 percent mortality for propeller entrainment is a reasonable level to use in the modeling.

NMFS realizes that this model is crude in its estimates. The zones of effects for water entrainment by the propellers (inflow zone) are calculated only for the diameter of a given propeller along the length of the ship channel. Studies by Maynord (2000c) indicated that the inflow zone for barge tows on the Mississippi River extend slightly beyond the beam of the tow (about 20 percent wider than the beam of the tow from centerline). Therefore, NMFS calculations may be underestimating the true volume of water entrained by the ship's propeller during its transit of the DWSC. Likewise, NMFS does not have any data for potential avoidance of juvenile and adult salmonids to oncoming shipping. However, the data gathered by the FWS trawls should represent a reasonable approximation of fish density that a ship would encounter in the channel. The trawling activities involve motorized vessels dragging a net through the waters of the San Joaquin River channel, which creates a substantial disturbance within the water column. The speed of the trawl is quite slow, generally less than 5 mph, providing ample opportunity for fish to escape the net by either moving laterally or vertically in the water column. Oncoming shipping would be moving at a faster rate than the trawl vessels and would take up a considerably greater percentage of the channel's cross section (approximately 30 percent for a 90 foot wide beam). The deep draft of the commercial shipping would preclude fish from moving vertically into deeper waters to avoid the oncoming ship, and the greater beam would necessitate moving greater lateral distances to avoid the oncoming ship.

As stated by the Port, ships moving through the channel would be traveling at 8 to 10 mph (3,600 mm to 4,500 mm per second). This is equivalent to approximately 40 to 50 times the length of an average sized smolt (90 mm). A smolt located along the sailing line of a vessel would have to swim at least 18,000 mm to escape the predicted zone of inflow for a ship with a beam of 30 meters. The maximum burst swimming speed for juvenile salmonids is approximately 10 times their body length (Webb 1995) or 900 mm/sec. At maximum swimming velocity, a 90 mm smolt would take 20 seconds to cover the distance from the ship's sailing line to the outside margins of the zone of inflow. Twenty seconds is at the limit of salmonid burst swimming duration (approximately 15 seconds) and any fish that exerted this type of energetic output would be expected to be exhausted by the activity. In 20 seconds, the vessel would have moved 72,000 to 90,000 mm (72 to 90 meters or approximately one football field in length) forward along its course of travel. Any fish along the centerline of travel would have to initiate its escape response at least 100 meters ahead of the ship in order to assure its movement out of the inflow zone. Although a salmonid would easily be able to detect the ship's propulsion system at these distances, data is lacking as to the critical distances at which a salmonid would exhibit escape responses as a result of the increasing noise levels. At 100 meters in front of the bow of an oncoming ship, the propulsion unit of a ship and its propeller will be an additional 100 to 200 meters further distant from this point due to the length of the ship. Therefore the noise source as detected by the fish 100 meters in front of the ship actually would be 200 to 300 meters distant.

Fish densities, as calculated by the FWS during their salmon monitoring trawls in the San Joaquin River and at Chipps Island indicate that the relative density of fish in the river water column is quite low (Please see Table 11). The FWS calculated Chinook salmon densities per 10,000 m^3 of water sampled for their mid-water and Kodiak trawls. Fish densities for beach seines in different locations in the Delta were typically higher than the data from the trawls; however this may be a reflection of the different capture efficiencies of the two methods as well as behavioral characteristics of the fish. Fish density data was presented by year, month and run-type in the FWS annual reports (FWS 2001b, 2003b) and also by total capture (Cadrett 2005). From tables 12a, b, and c, it is apparent that the highest mortalities are expected to occur during the winter-spring emigration period for juvenile salmonids, and are likely to occur at the western edge of the Delta. This is a reflection of the different contributions that the San Joaquin River basin stocks and Sacramento River basin stocks make to the overall fish density measurements. Further up the San Joaquin River near Jersey Point and Prisoners Point, the majority of fish are most likely from the San Joaquin River basin, although some will have Sacramento River origins due to the cross Delta flows created by the State and Federal pumping facilities in the south Delta. In order to account for this, NMFS weighted fish densities from the available data for Chipps Island and the San Joaquin River sites and extrapolated fish densities at the San Joaquin River sites for months in which sampling did not occur on the San Joaquin River. The fish densities for each reach were then used to calculate the expected rate of entrainment for each river segment over a one year period.

The projected entrainment values for Chinook salmon on the San Joaquin River due to continued shipping activities, represent a substantial adverse effect on this population of fish. Sacramento River winter-run Chinook salmon will encounter annual entrainment mortalities in the lower segment of the San Joaquin River between Blind Point and the Port of Pittsburg ranging between 443 fish (i.e., assuming an 8 mph transit with a 4 meter propeller and a pitch ratio of 0.5) to almost 5,400 fish (i.e. assuming an 5 mph transit with a 6 meter propeller and a pitch ratio of 1.5). Spring-run and fall-run Chinook salmon will have an estimated mortality rate of nearly 33,000 fish to almost 400,000 fish under the same two scenarios, respectively. Also, in the upstream portions of the San Joaquin River between Blind Point and the Port an additional 11,000 fish to approximately 111,000 fall-/spring-run Chinook salmon will be entrained using the same two scenarios described above.

In order to approximate the entrainment of steelhead smolts in the San Joaquin River, a rough rule of thumb for the ratio between Chinook salmon captured in trawls and steelhead captured is 1000 Chinook salmon to 1 steelhead (D. Marston, CDFG 2004). Due to the lack of specific density data for steelhead due to their rare level of capture in trawls, NMFS uses this as a "best guess" estimate for deriving the impacts to steelhead in the DWSC. Therefore, the best estimate NMFS can make for steelhead is a range of 40 to 500 steelhead smolts on an annual basis for the expected increase in shipping traffic using the two scenarios described above. The confidence in this range is low based on the different swimming characteristics between smaller Chinook salmon smolts and larger steelhead smolts. Although larger steelhead smolts should be able to avoid the passage of ships more readily than Chinook salmon smolts, those that do encounter the propellers will have a much higher mortality rate than the smaller salmon smolts, as indicated by the results of previous turbine mortality studies (Gloss and Wahl 1983; Dubois and Gloss 1993).

e. *Shipping Noise*

Ships under power produce a substantial amount of mechanical and flow induced noise from the power plant, propeller, and hull turbulence. Measurements of sound intensity from commercial shipping have shown levels of 180 dB (ref. 1 μPa) at the point source. This level of noise can damage sensory hairs in a fish's inner ears as previously described in this opinion. Behavioral changes and loss of hearing sensitivity have been documented in some fish species at sound levels above 145 dB. The narrow confines of the channel would indicate that the excessive noise levels generated by the passage of a commercial vessel would extend essentially from bank to bank in the DWSC, thus subjecting all fish within the confines of the channel to adverse noise conditions. The rapid passage of the ship past a given point will somewhat attenuate the adverse effects by decreasing the duration of the intense sound levels, but some temporary and permanent effects can be anticipated to occur, depending on the proximity of the exposed fish to the sound source.

As stated previously for dredging associated noises, the loss of hearing sensitivity may adversely affect a salmonid's ability to orient itself (*i.e.*, due to vestibular damage), detect predators, locate prey, or sense their acoustic environment. Fish also may exhibit noise-induced avoidance behavior that causes them to move into less suitable habitat. In the proposed action, this may result in salmonids fleeing the shipping associated noises and moving into the channel's shallowest margins. In the delta, the channel margins have characteristics such as submerged and emergent vegetation (*e.g.*, *Egeria*) and rock rip-rapped levees where predators such as largemouth bass and sunfish are likely to occur in greater numbers than the nearshore waters. This scenario increases the smolts exposure to predation by these piscine predators. Likewise, chronic noise exposure can reduce their ability to detect piscine predators either by reducing the sensitivity of the auditory response in the exposed salmonid or masking the noise of an approaching predator.

VI. CUMULATIVE EFFECTS

For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in the Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

The Delta and East Bay regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial, and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. The project site is within the region controlled by San Joaquin County Council of Governments, and the cities of Brentwood, Antioch, and Oakley. The General Plans for the cities of Stockton, Brentwood, Antioch, and Oakley and their surrounding communities anticipate rapid growth for several decades to come. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east, and Highway 4 in the west.

Increased urbanization also is expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. In addition to recreational boating, commercial vessel traffic is expected to increase with the redevelopment plans of the Port of Stockton. Portions of this redevelopment plan have already been analyzed by NMFS for the West Complex (formerly Rough and Ready Island) but the redevelopment of the East Complex, which currently does not have a Federal action associated with it, will also increase vessel traffic as the Port becomes more modernized. Commercial vessel traffic is expected to create substantial entrainment of aquatic organisms through ship propellers as the vessels transit the shipping channel from Suisun Bay to the Port and back again. In addition, the hydrodynamics of the vessel traffic in the confines of the channel will create sediment resuspension, and localized zones of high turbulence and shear forces. These physical effects are expected to adversely affect aquatic organisms, including both listed salmonids and North American green sturgeon resulting in death or injury.

VII. INTEGRATION AND SYNTHESIS

In general, the direct adverse effects to Chinook salmon and steelhead in the DWSC will be substantially attenuated by the work window proposed by the Corps, which will greatly reduce the exposure of listed salmonids. Dredging activities are to be restricted to the period between June 1 and December 31, although effluent from the DMP sites may continue to enter the DWSC for a period of time (*e.g.*, 1 month) after the work window ends. Bank stabilization activities will occur for a briefer period (*i.e.*, from June 15 through November 30) within the larger work window. The proposed work window will avoid the majority of steelhead migration through the DWSC from the San Joaquin and Sacramento River basins. In this area, adult and juvenile steelhead are expected to be exposed primarily during late November and December, when cool and rainy weather is likely to promote migration. Likewise, early downstream juvenile emigrants of the winter-run and spring-run Chinook salmon runs from the Sacramento River basin should not enter the Delta until at least late October and more likely late November to early December when dredging is nearing completion for the year. Few adult winter-run Chinook salmon and no adult spring-run Chinook salmon are expected to be exposed to the direct adverse effects of the project. Green sturgeon presence within the action area is considered to be year-round, with juveniles entering the Delta during the late summer and fall and potentially rearing there for several months to years before migrating to the ocean. However, because Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and North American green sturgeon spawning populations occur in the Sacramento River drainage and not in the San Joaquin River drainage, relatively few fish from these ESUs/DPSs are expected to be exposed to the effects of the project, and then only in the lower 22 miles of the action area.

The proposed action is expected to contribute to the continuation of poor quality habitat conditions in the DWSC that may be experienced by fish present throughout the year. These indirect impacts include the exacerbation of the existing low DO problem in the DWSC, and maintaining the habitat as a channelized, riprapped corridor.

A. Effects on Listed and Proposed Species

1. Turbidity and Suspended Sediment

The short-term effects of the proposed project are expected to result in an increase of approximately 10 percent in the near field suspended sediment ambient loads, which should not greatly change conditions in the DWSC compared to background turbidity levels. Furthermore, the increased turbidity zone should be concentrated near the bottom of the channel within close proximity of the cutterhead before being diluted by water flow in the channel. Therefore, listed salmonids in the action area are not expected to be directly affected by the turbidity levels generated by the project, as salmonids should occupy the shallower, near surface water levels during emigration. Overall, the changes in turbidity and suspended sediment associated with this project therefore are expected to adversely affect listed species primarily by low-level, long-term alteration of habitat conditions, which may affect feeding or predation rates. The potential for the increase in suspended sediment to adversely affect green sturgeon is unclear. Although sturgeon are demersal fish closely associated with the bottom substrate, and therefore could be exposed to the elevated zones of turbidity along the bottom, they also are well-suited for these conditions. In particular, they feed by taste and feel with their barbels, even shoveling up sediment with their snouts when searching for food (Moyle 2002). Adverse effects are more likely to occur from entrainment of small individuals in the dredge.

2. Contaminants

The contaminants associated with the dredge material and the exposure of the new horizon may adversely affect exposed aquatic organisms. Of the several contaminants identified in the sediment, only copper appears to be sufficiently elevated to pose a direct risk to migrating salmonids in the DWSC. Copper constituents are expected to exceed the recommended threshold effects concentrations as stated in the sediment quality guidelines of Buchman (1999) and MacDonald *et al.* (2000) and therefore would be expected to exceed protective water quality guidelines in the Basin Plan. In addition, the extreme sensitivity of salmonids to copper and the short exposure times required to elicit negative effects makes any increased levels of copper potentially problematic. The other levels of contaminants present in the sediment may not exceed the acute toxicity concentrations or the different water quality guidelines even if the sediment quality criteria are exceeded. Nevertheless, their elevated concentrations do present an increased risk to the health of exposed salmonids even though the exposure may not result in mortality.

The DMP sites present several avenues to adversely impact both adult and juvenile Central Valley steelhead, Sacramento River winter-run Chinook salmon, and Central Valley spring-run Chinook salmon. As mentioned previously, the associated decant water plume may contain elevated levels of heavy metals, ammonia, organic compounds, and fine sediments. Heavy metals can adversely affect the fish's ability to navigate to its natal stream by impairing olfactory response (copper) and neurological activities (several different metals and organic compounds like pesticides). Other physiological processes can be impaired following metal exposure including reproductive performance and fertility. The level of exposure is complicated by the movement of the adult fish through the plume, the concentration of chemicals in the plume, and the duration of the fish's exposure to the plume.

Decant water can continue to discharge for several days to weeks from the DMP sites following the cessation of active dredging in late December and can therefore pose a risk to migrating fish migrating later in the season than would be exposed to the dredging activities. On the other hand, the decant waters are not expected to be experienced by all migrating salmonids to the same degree due to the temporal and spatial variances of the swim path of the fish and the location of the discharge plume. Fish that migrate near the riverbank will be more likely than fish in the middle of the channel to encounter the discharge plume during their upstream movements. Likewise fish that move during periods of discharge will have the potential to encounter the discharge plume compared to fish that move through the river system when there is no discharge.

3. <u>Dredge Entrainment</u>

The hydraulic suction head of the dredge creates a zone of inflow around the cutterhead of the dredge. Animals that venture too close to the cutterhead have the potential to be entrained into the suction pipeline of the dredge and carried to the DMP site on shore. As described previously, the Corps has indicated that dredging will take place between June 1 and December 31 to avoid the majority of listed salmonids in the DWSC. The dredge will be operated at least 20 feet below the water surface, with the hydraulic suction and cutterhead operating only in the bottom substrate. The cutterhead may be raised briefly to clear obstructions, but never more than 3 feet above the substrate. NMFS believe these measures to be generally protective of salmonids that may be within the dredging area. NMFS calculated that the velocity of the inflow water surrounding the orifice of the dredge head is below the critical burst swimming speed of juvenile salmonids, even within 0.5 meters of the cutterhead. Therefore, even if a juvenile salmonid were in close proximity to the cutterhead at the 20-foot depth, which is not likely, the fish would still be able to escape the inflow zone of the dredge and avoid entrainment. It is NMFS' position that fish entrainment by the hydraulic dredging in this project scenario represents a very unlikely source of take due to the timing of dredging, the depth, and the flow fields around this particular dredging operation. In order for entrainment of steelhead (or other salmonids) to occur, the fish would have to be concentrated around the dredge head or the dredge operated at water depths where the salmonids would normally be aggregated.

The behavior of sturgeon places them more at risk than salmonids for entrainment into the hydraulic dredge. Sturgeon are benthically-oriented fish, maintaining position on or just above the bottom substrate. This places them within the operating zone of the hydraulic dredge. Sturgeon also tend to preferentially congregate in deep holes or channels where they “rest” or hold position for long periods of time. These deep holes along the channel of the DWSC would place congregating sturgeon in the path of the dredging operations. An additional concern is the “lethargic” resting behavior of sturgeon, which could potentially allow the dredges to come within close proximity of the fish prior to eliciting an escape response. Reine and Clarke (1998) reported that white sturgeon on the Columbia River were entrained at an overall rate of 0.015 fish/cubic yard of material dredged, but were entrained in substantial numbers primarily from one location locally known as the “sturgeon hole.” These fish ranged in size from 30 cm to 50 cm, which would correspond to juvenile-sized fish. These sizes are similar to those that would be expected to be found in the Delta.

NMFS believes that the dredging action will remove benthic invertebrates from the channel environment along length of the DWSC, which represents a loss of forage base to outmigrating salmonids and rearing green sturgeon. The time needed to recolonize the dredged area is unknown and is complicated by the maintenance dredging cycle of 3.5 years in the Port of Stockton reach and the 4 year cycle in the western Delta reach near Antioch. These short dredging cycles may preclude a “natural climax” benthic invertebrate assemblage from re-establishing itself. However, outmigrating salmonids and rearing green sturgeon should be able to find alternative foods and foraging areas outside of the channel and in adjoining channels feeding into the DWSC. Overall, the maintenance dredging is not likely to change the benthic habitat to the extent that listed species would be adversely affected in the five reaches to be dredged, particularly in the middle reaches of the DWSC that have dredging cycles that are greater than a decade.

4. Acoustic Impacts of Dredging

The range of elevated noise around the dredging equipment may cause temporary behavioral or loss of hearing to affected fish. The primary impact to salmonids will be to adult steelhead migrating upstream during the fall while dredging operations are being conducted. As projected by the Corps, the dredging activities will be conducted until the end of December, and at a frequency of about every 3.5 to 4 years (maintenance dredging of RM 8 to 12 and RM 37 to 41). Migrating adult salmonids may be forced to avoid the elevated noise of the dredging operations by swimming to the far sides of the DWSC or holding until there is a break in the dredging actions. There is a potential for these fish to suffer a temporary loss of hearing sensitivity at the expected noise levels generated by the dredge. It is not anticipated that a significant number of juveniles will be impacted as the primary migration period will occur after the cessation of dredging activities, but loss of hearing sensitivities in affected individuals would likely expose them to higher risks of predation. Fish with impacted hearing capacities will have a lower ability to detect predators and may be unable to maintain position in the water column (inner ear equilibrium factors).

The hearing sensitivity of green sturgeon is unknown; therefore, NMFS must make its assessment based on the general behavior of fish to noise. Given the sedentary behavior of sturgeon, their location on the bottom in close proximity to the cutterhead, and their likelihood of being present in the dredging action area throughout the work window, some individuals are expected to experience elevated sound levels which could adversely affect their hearing and behavior.

5. <u>Interrelated and Interdependent Activities</u>

NMFS considers that significant adverse impacts related to the project will be due to the perpetuation of shipping traffic made possible by the maintenance of the DWSC at -35 feet MLLW. Currently, the volume of shipping traffic is estimated to be approximately 150 to 250 vessels per year.

a. *Shipping Related Changes in Channel Hydrodynamics*

The passage of large hulled ships through the confines of the DWSC will create hydrodynamic forces on the channel's sides and bottoms which are expected to adversely affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead along the length of the channel. Shear forces generated by the movement of the hull through the water will create turbulent flows along the length of the hull. These forces may exceed the threshold at which physical damage can occur to the tissues of the exposed salmonids causing both sublethal and lethal internal injuries. In addition to these obvious physical injuries, the turbulent flow can cause disorientation and erratic swimming behavior following exposure. This can elevate the susceptibility of smaller fish to predation by larger piscivorous fish in the channel, such as striped bass and largemouth bass.

In addition to the turbulent flow along the hull, effects such as bank drawdown and transverse wakes can cause adverse effects in the wake of the ship's passage. The drawdown and following transverse wake can cause issues of stranding where bottom configurations accentuate these physical aspects of the ship's passage. Although studies on the Mississippi and Columbia River systems showed stranding to be a minor impact following ship passage, those river systems predominantly had soft, sloping banks in the study areas. The configuration of the Delta's rock rip-rapped banks may have different results for stranding.

Due to the complex interaction of the ship's hull characteristics, channel geometry, and distance away from the ship's passage, direct enumeration of fish impacted by the passage of the hull through the water is difficult to state. The Port of Stockton has estimated that on average there will be one ship a day traversing the DWSC on its way to the Port. The period of time it takes for a salmonid to make the journey from the Port to Chipps Island may range from several days to several weeks, with each day spent in the system seeing an average of one ship pass. Therefore, NMFS believes that each fish utilizing the San Joaquin River as a migration corridor will be subjected to numerous ship passages during its migration through the system, whether it is a juvenile or an adult.

In addition to the direct impacts of the hydrodynamic forces on the exposed fish, the passage of vessels through the ship channel will cause substantial resuspension of bottom sediments. As has been previously stated, these sediments, particularly near the Port, are contaminated with several different COCs. The continual bottom disturbance by hull turbulence and propeller jets increases the exposure of these chemicals to the water column, where their presence will impact fish moving through the channel. Furthermore, the suspension of this predominately fine organic material from the bottom will decrease the amount of oxygen in the water column through oxidative processes, both biological and chemical in nature. This will continue to exacerbate the low DO conditions in the DWSC as reduced material is oxidized. This process may also enhance the toxicity of contaminants, as their valence state changes. This condition will be chronic, based on the average of one ship passage per day and the settling rate of this fine particulate matter.

b. *Shipping-Related Pollution*

The increase in shipping will have a concomitant increase in shipping-related pollution. As previously stated, all salmonids making use of the San Joaquin River as a migratory avenue will be subjected to several ship passages during their time in the channel. The heaviest concentration of ship-related pollution is expected to occur within the Port itself, where ships are berthed for extended periods and flushing flows are reduced. This will primarily affect Central Valley steelhead from both the Calaveras River and San Joaquin River watersheds. Sacramento River winter-run and Central Valley spring-run Chinook salmon, as well as Central Valley steelhead originating from the Sacramento River watershed, will be exposed to pollutants originating from ships in transit along the San Joaquin River further downstream from the Port. All fish within the DWSC will be exposed to some level of these pollutants, although not all fish will experience morbidity or mortality.

Since shipping occurs year round in the Port, both juveniles and adults of the different ESUs will be exposed to ship-based pollutants. For those fish that survive the immediate pollutant exposure, effects from pollutant exposures may manifest themselves at a later time, after fish have moved out of the DWSC and are apparently "safe" from the pollutants. An example of this pathology is the increased mortality due to viral and bacterial infections (*e.g.*, *vibrio*) in salmon smolts entering the ocean, which have reduced immune responses due to their previous exposure to petroleum products or other pollutants in the estuaries of their natal watersheds (Arkoosh 1998, 2001). These elevated mortality rates were discernible several weeks after the smolts entered the marine environment.

c. *Propeller Entrainment*

Based on the modeling projections made by NMFS, the current volume of shipping traffic in the DWSC could see levels of mortality of Sacramento River winter-run Chinook salmon juveniles of approximately 450 fish to over 5,000 fish, depending on the size and speed of the ship. Likewise, the combined grouping of juveniles from the Central Valley fall- and spring-run

Chinook salmon ESUs could experience levels of mortalities ranging from 44,000 fish to 500,000 fish for the projected volume of ship traffic. Based on the relative sizes of the outmigrant populations, NMFS expects approximately 2 percent of these to be spring-run fish. Using the hypothesized ratio of Chinook salmon density to steelhead density in the Delta's fish monitoring studies, the loss of steelhead smolts to propeller entrainment could range from 40 to 500 additional fish in the DWSC.

These take estimates are very conservative as they do not take into account the total zone of inflow around the ship created by the propeller's pull, nor do they take into account the multiple times a given fish may be exposed to shipping traffic while in the DWSC. In addition, any disorienting effects on the fish's swimming ability resulting from the turbulent flow fields around the hull or in the propeller wash are not considered. It is reasonable to conclude that additional fish may fall prey to predators after becoming disoriented in the flow fields surrounding the ships.

While the above calculations concern juvenile fish and smolts, adult fish also may suffer injury or mortality from the passage of ships and interactions with the ship's propellers. Recent discussions with CDFG staff have indicated that adult sturgeon have been recovered with obvious propeller scars, some resulting in death, during fish monitoring surveys (Gingras 2005). These incidents occurred immediately following the passage of large ocean going ships in the San Joaquin River channel.

d. *Shipping Noise*

The passage of ships within the confines of the DWSC will expose migrating salmonids to excessive levels of underwater acoustic noise. Measurements of ocean-going ships, such as use the DWSC, have indicated that the underwater noise produced by these ships can reach or exceed 180 dB (reference 1 µPa) at the source. This level of noise is sufficient to cause internal inner ear injuries (*e.g*., ablation of sensory hairs) that appear permanent in nature in other fish species examined (*e.g.*, red snapper). The loss of these sensory hairs reduces the fish's ability to react to the acoustic environment around it, which will reduce its ability to react to predators and prey. The width of the DWSC for the majority of its length is narrow enough to preclude avoidance of the increased noise levels emanating from the ship, thus all fish migrating through the DWSC that encounter a ship passing through the channel will be exposed to potentially damaging noise levels. Listed salmonids passing through the DWSC may encounter several ocean going ships (based on one ship per day traffic) on a multi-day journey through the Delta. Given a channel width of 200 meters (approximately 650 feet) the sound pressure level at each bank will be approximately 140 dB, which is in the range to at least cause behavioral modifications and temporary loss of hearing sensitivities. This acoustic noise level is in addition to the "normal" recreational boating noise generated by personal vessels in the DWSC. The combined level of sound input to the DWSC would indicate that migrating fish are subject to a continual barrage of high-energy noise during their entire migratory passage through the DWSC from both shipping and recreational vessels. The cumulative impacts of this condition may lead to reduced physiological status in the exposed fish based on the stressful nature of chronic noise input.

B. Effects on Species Likelihood of Survival and Recovery

1. Central Valley Steelhead

NMFS anticipates that the proposed project will result in the exposure of a small number of adult and juvenile Central Valley steelhead to increased levels of turbidity and suspended sediment, toxic chemicals including heavy metals and ammonia, entrainment, and noise. The exposures to toxic chemicals and noise in particular are expected to adversely affect a small number of individuals. Noise may delay or impede fish migration causing increased energy expenditure by affected individuals. The elevated stress levels and toxics may degrade the fish's health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Individuals that appear different in their behavior attract predators, and thus experience higher mortality due to predator attacks. Prolonged exposure to even low levels of toxics, as would occur in low-flow conditions when water residence time in the DWSC is measured in days to weeks, would enhance the potential uptake of metals and other contaminants by feeding juveniles.

Since the populations of adult steelhead that migrate into the Calaveras and San Joaquin Rivers are quite small, even the loss of a few adult fish may have substantial adverse effects on juvenile age class sizes in succeeding years. Estimates of adult escapement of steelhead to these watersheds are typically only a few dozen or so. This is reflected by the low number of smolts captured by monitoring activities throughout the year in different tributaries (*i.e.*, rotary screw traps on the Stanislaus, Tuolumne, Merced, and Calaveras Rivers, and the Mossdale trawls on the San Joaquin River below the confluence of these three east side tributaries) in which only a few dozen smolts to several hundred smolts are collected each year (Marston 2004, Cramer 2005). These capture numbers have been extrapolated to estimate an annual population of only a few thousand juvenile steelhead smolts basin-wide in the San Joaquin River region. The Stanislaus River weir, which is used to count adult steelhead passing through the counting chamber or dead carcasses floating back onto the weir, has only recorded a few adult fish each year it has been in use. This is indicative of the low escapement numbers for adult steelhead in this watershed (Cramer 2005). The other watersheds are thought to have similar or even lower numbers based on the superiority of the Stanislaus River in terms of habitat and water quality for Central Valley steelhead.

The loss of one individual female's reproductive capacity either through mortality or reproductive degradation related to toxicant exposure can have a relatively high impact on a given watershed's potential population if the number of adults returning to each stream is low. Loss of one female with an expected egg capacity of 5,000 eggs represents approximately 50 to 100 smolts returning to the ocean (Good *et al*. 2005). Even though the loss of a few steelhead adults on either the San Joaquin River or Calaveras River watersheds could have significant impacts to future juvenile steelhead year classes in these systems, this is not expected to reduce the likelihood of survival and recovery of the Central Valley steelhead DPS. This is due to the relatively small contribution that these watersheds make to the entire Central Valley steelhead DPS. Straying of adults from other watersheds may help to sustain these small runs over the long term, replacing fish lost to natural and anthropogenic causes.

Impacts related to shipping traffic would occur year round and expose potentially the whole San Joaquin River population of Central Valley steelhead to the adverse effects described in the effects analysis. The frequency of ship transits in the DWSC and the time required for adult and juvenile steelhead to transit the San Joaquin River portion of the Delta would indicate that fish would have a high probability of encountering a ship at least once during their migration, and perhaps several times, depending on the route they chose to move through the myriad of Delta channels.

2. Sacramento River Winter-run Chinook salmon

NMFS does not anticipate that Sacramento River winter-run Chinook salmon adults will occur in any great numbers within the action area during the proposed work windows for dredging and bank stabilization. Also, NMFS does not expect that juvenile winter-run Chinook salmon will be present in the action area until late in the dredging work window. Decant water entering the San Joaquin River channel below RM 22 (Mokelumne River confluence), where winter-run Chinook salmon are most likely to occur, will come from one of four DMP sites: Bradford Island, the Expanded Scour Pit, McCormick Pit or Jersey Island. Only the lower dredging section between RM 8 and RM 12 has a short dredging return cycle (4 years). The two remaining dredging sections (RM 13 to 15 and RM 15 to 16) have dredging cycles of over 10 years. The DMP sites on Sherman Island (Expanded Scour Pit and McCormick Pit), Jersey Island and Bradford Island would receive dredge spoils from these dredging reaches. Fish exposure to DMP effluent would be intermittent and based on local hydrology, tides, and the spatial and temporal position of migrating fish. The preceding information indicates overall that exposure of Sacramento River winter-run Chinook salmon to effluent from the DMP sites should be infrequent and involve very few individuals, although decant water can continue to discharge for several days to weeks from the DMP sites following the cessation of active dredging in late December. Exposed individuals are expected to be outmigrating juveniles.

Unlike steelhead from the San Joaquin River drainage, the loss of these few Sacramento River winter-run Chinook salmon smolts is not expected to decrease the number of returning adults, because of the large number of smolts are produced by the population. Since no spawning or major freshwater rearing habitat will be affected by the proposed activities, impacts on spawning survival and survival from egg to smolt are not expected. The very small loss of winter-run smolts anticipated during the dredging actions would be unlikely to result in a change in adult returns, because the number expected to be lost is small in comparison to the number of smolts produced and likely to survive to become adults.

Impacts related to shipping traffic would occur year round and expose potentially a small, but significant proportion of the population of Sacramento River winter-run Chinook salmon to the adverse conditions described in the effects analysis. The frequency of ship transits in the DWSC and the time required for adult and juvenile winter-run Chinook salmon to transit the section of the San Joaquin River from the confluence of the Mokelumne River to RM 4 would indicate that fish would have a high probability of encountering a ship at least once during their migration, and perhaps several times, depending on the route they took through the Delta’s channels. Fish that remained entirely within the Sacramento River channel would avoid most of the shipping effects, but could still encounter ships within Suisun Bay, although at a substantially lower rate due to the vast differences in the cross section of the bay versus the river channel and the percentage of that cross section taken up by the ship's beam and draft.

3. Central Valley Spring-run Chinook salmon

NMFS does not anticipate that Central Valley spring-run Chinook salmon adults will occur in the action area during the dredging work window or soon after its closure, and therefore are not likely to be directly affected by activities such as the dredging or bank stabilization activities. Also, the likelihood of juvenile spring-run Chinook salmon being present in the San Joaquin River during the dredging work window is low. Yearling fish may appear in the San Joaquin River as early as late October, but are not likely to occur in any substantial numbers until after February when the pulse of emigrating juvenile spring-run Chinook salmon begin to enter the Delta. The exposure potential of spring-run Chinook salmon to the decant water is expected to involve few fish, as the DMP sites are expected to have drained prior to the influx of juveniles into the waters of the western Delta, unless there is substantial winter precipitation.

As with Sacramento River winter-run Chinook salmon, no spawning or major freshwater rearing habitat will be affected by the proposed activities, so impacts on spawning survival and survival from egg to smolt are not expected. The very small loss of spring-run smolts anticipated would be unlikely to result in a change in adult returns, because the number expected to be lost is small in comparison to the number of smolts produced and likely to survive to become adults.

As previously mentioned for Central Valley steelhead and Sacramento River winter-run Chinook salmon, encounters with shipping traffic will occur during all months of Central Valley spring-run Chinook salmon migrations for both adults and juveniles. NMFS believes that the impact to spring-run Chinook salmon will be confined to the lower reaches of the DWSC and portions of Suisun Bay as was described for the winter-run Chinook salmon migrants.

4. Southern DPS of North American Green Sturgeon

Sturgeon are expected to be particularly vulnerable to the adverse effects of dredging due to their benthic-oriented behavior which puts them in close contact with the contaminated sediment horizon. Their "inactive" resting behavior on substrate puts them in dermal contact with contaminated sites which can lead to lesions and the production of tumors from materials in the substrate. Sturgeon are also benthic invertebrate feeders that forage on organisms that can sequester contaminants at much higher levels than the ambient water or sediment content, such as the Asian clams *Corbicula* and *Potamocorbula* that are prevalent in the Delta. The great longevity of sturgeons also places them at risk for the bioaccumulation of contaminants to levels that create physiologically adverse conditions within the body of the fish. Because they prefer deep pools, green sturgeon may have some reduced risk of exposure to effluent from DMD sites, which will be released in the shallow water margins of the river channel.

Little is known about the migratory habits and patterns of either adult or juvenile green sturgeon in the Delta region. The basic pattern described for adult green sturgeon migrations into the Delta region from the San Francisco Bay estuary is that fish enter the Delta region starting in late winter or early spring and migrate upstream towards the stretch of the Sacramento River between

Red Bluff and Keswick Dam. After spawning, adults return downstream and re-enter the Delta towards late summer and fall (based on behavior of sturgeon in the Klamath and Rogue River systems). Juvenile and larval green sturgeon begin to show up in rotary screw trap catches along the Sacramento River starting in summer (Beamesderfer *et al.* 2004) and could be expected to reach the Delta by fall. The extent and duration of rearing in the Delta is unclear (*i.e.*, months to years), but NMFS believes that juvenile green sturgeon, including sub-adults, could be found during any month of the year within the waters of the Delta. Therefore, both adult and juvenile green sturgeon have the potential to be adversely affected by exposure to toxic chemicals, entrainment, and noise due to the project. These fish are likely to be in the vicinity of the lowermost dredging, DMP, and bank stabilization sites year-round. However, because green sturgeon apparently spawn only in the Sacramento River, relatively few green sturgeon are expected to be occur in the San Joaquin River drainage and be exposed to the adverse effects of the project.

Due to the lack of population abundance information regarding the Southern DPS of North American green sturgeon, a variety of estimates must be utilized to determine the range of effects resulting from the take of a small number of green sturgeon. Compared to the estimated population sizes suggested by the CDFG tagging efforts (CDFG 2002), juvenile and sub-adult captures passing Red Bluff Diversion Dam, and past IEP sampling efforts, the lethal take would remove a small proportion of the adult and sub-adult North American green sturgeon population in the Sacramento River watershed. Ratios of tagged white to green sturgeon in San Pablo Bay have generated population estimates averaging 12,499 sub-adult and adult green sturgeon. Captures of juvenile and sub-adult green sturgeon passing Red Bluff Diversion Dam have exceeded 2,000 individuals in some years. Incidental take of both adult and juvenile North American green sturgeon is expected to represent a relatively small proportion of the standing population and is not expected to jeopardize the continued existence of the Southern DPS of North American green sturgeon.

It is hard to predict the impact of shipping on green sturgeon due to the lack of specific information on migratory behavior of fish in the San Joaquin River system. However, due to the preference for sturgeon to occupy deep channels and holes in a river system, it is believed that all fish occupying the San Joaquin River will be in the DWSC or within close proximity to it. This places them at great risk to propeller entrainment or the other adverse effects of ship passage.

C. Effects of the Proposed Action on Critical Habitat

Routine maintenance dredging will prevent future shoaling, continue to remove and expose new horizons of sediment with each dredging cycle, and periodically contribute to the suspended sediment, noise, and contaminant levels of the action area. The bathymetry manipulations will perpetuate the conditions which currently contribute to the degraded water quality in the San Joaquin River and upper Stockton DWSC near the Port of Stockton, which is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat that will be affected include freshwater rearing sites for juveniles and freshwater migration corridors for both juveniles and adults. The dredged DWSC will act as a collecting basin for materials carried along by the flow of the San Joaquin River above Channel Point. Furthermore, the maintenance of the cross-sectional area of the channel will maintain the artificial volume of the channel compared to that which would naturally occur, and thus is expected to slow down the flushing velocity of the ambient river flow, and allow suspended material to settle out of the water column within the DWSC. The constant adjusting of the channel cross section from that which normally occurs through equilibrium of the natural energy and sediment budgets to those of the artificially maintained channel dimensions perpetuates the need for dredging and the reduction of flow velocity throughout the channel.

The current water quality conditions in the DWSC between the Port and Turner Cut downstream are dominated by a severe low DO condition during low flow conditions. As indicated in Table 5 (Appendix A), there are frequent depressions below the 5 mg/L DO water quality criteria during the period when steelhead migrate through the DWSC adjacent to the West Complex. These conditions will continue into the future under current operations and NMFS anticipates that they will be exacerbated by the development of additional Port activities and their expansion plans.

The long-term effects of bank stabilization activities will be to maintain the currently channelized and riprapped conditions characterizing the banks of the DWSC. These conditions will be periodically worsened as the limited riparian vegetation that may be present is removed to facilitate replacement of riprap. In general, the DWSC will continue to provide relatively uniform, deep, open habitat that lacks the suitable shallow water resting, sheltering, and feeding locations which characterize the freshwater rearing sites (a PCE of critical habitat) on which juvenile steelhead and other salmonids depend for adequate growth and protection from predators. The reduction in shade may contribute to elevated water temperatures in the Delta, but this should not be of great concern because listed salmonids are expected to be present primarily in late fall, winter, and spring. Green sturgeon may be less affected by these conditions as they tend to occupy deep pools. Although the proposed action will prevent the San Joaquin River from reestablishing natural hydrological conditions and characteristics, it is not anticipated to further degrade an already highly degraded system. The critical habitat baseline is not anticipated to change significantly from the currently proposed action.

VIII. CONCLUSION

A. Formal Consultation

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline, the effects of the proposed Stockton DWSC Maintenance Dredging and Bank Stabilization project, and the cumulative effects, it is NMFS' biological opinion that the Stockton DWSC Dredging and Bank Stabilization project, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead, or result in the destruction or adverse modification of the designated critical habitat for Central Valley steelhead.

B. Conference Consultation

After reviewing the best available scientific and commercial information, the current status of the southern DPS of North American green sturgeon, the environmental baseline, the effects of the proposed Stockton DWSC Maintenance Dredging and Bank Stabilization project, and the cumulative effects, it is NMFS' biological opinion that the Stockton DWSC Maintenance Dredging and Bank Stabilization project, as proposed, is not likely to jeopardize the continued existence of the southern DPS of North American green sturgeon.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement (ITS).

The measures described below are non-discretionary and must be undertaken by the Corps so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered in this ITS. If the Corps: (1) fails to assume and implement the terms and conditions of the ITS; and/or (2) fails to require the agents of the Corps to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps and the Corp's agents must report the progress of the action and its impact on the species to NMFS as specified in this ITS (50 CFR §402.14[i][3]).

While some measures described below are expected and intended to avoid, minimize, or monitor the take of North American green sturgeon, the prohibitions against taking of listed species in section 9 of the ESA do not apply to proposed North American green sturgeon unless and until the species is listed. However, NMFS advises the Corps to consider implementing the following reasonable and prudent measures for proposed North American green sturgeon. If this conference opinion for North American green sturgeon is adopted as a biological opinion following a listing, the measures for North American green sturgeon, with their implementing terms and conditions, will be nondiscretionary.

A. Amount or Extent of Take

NMFS anticipates that the proposed Stockton DWSC Maintenance Dredging and Bank Stabilization project and the associated shipping activities will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon. The incidental take is expected to be in the form of death, injury, harassment, and harm from sources such as contaminant resuspension, propeller entrainment, and depleted DO. Direct take of salmonids from the Corps' dredging activities (*e.g.*, entrainment in the dredge or exposure to resuspended contaminants) is expected to occur primarily to Central Valley steelhead and only during the month of December, when Central Valley steelhead are likely to occur throughout the DWSC. A low level of incidental take may also occur for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon that encounter dredging or levee stabilization actions in the lowermost 22 miles of the DWSC during November and December. Take from long-term impacts or changes to the action area (*e.g.*, impeded migration due to exacerbation of the low DO problem resulting from the bathymetry of the DWSC near the Port of Stockton, maintenance of the existing encounter rate with ship propellers in the DWSC, and loss of shallow water and riparian habitat in areas of bank stabilization) is expected to affect listed salmonids from November 1 through May 31, which includes the entire period when individuals from one or more of the listed ESUs or DPSs may be expected to occur in the action area.

North American green sturgeon are known to spawn only in the Sacramento River drainage, Therefore, NMFS assumes that like Chinook salmon and steelhead originating from the Sacramento River basin, green sturgeon are most likely to occur in the lowermost 22 miles of the Stockton DWSC. Green sturgeon are expected to occur in the action area year-round, although in greater numbers from April through October. Therefore, take from project activities is most likely to occur from June through October, due to overlap with the proposed work window. The occupation of benthic habitat by green sturgeon is expected to increase their vulnerability to entrainment by the dredge cutterhead and ship propellers compared to listed salmonids.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon taken will be difficult to quantify because dead, injured, or impaired individuals will be difficult to detect and recover. Take is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon juveniles and adults harmed, harassed, or killed due to acoustic damage associated with maintenance dredging of the Stockton DWSC from RM 4 to RM 41. Take of salmonids is expected to occur only during the month of December, and take of North American green sturgeon is expected to occur from June through October from acoustic impacts that exceed 150 dB (ref 1 µpascal), which NMFS considers the threshold of behavioral and physiological changes in exposed fish species, as measured at a depth of one meter in the water column and at a distance of 10 meters from the dredger. Only the Central Valley steelhead that have origins in the Calaveras River and San Joaquin River watersheds pass through the action area with any certainty. It is expected that fewer than 100 adult and 1,000 juvenile

Central Valley steelhead from the San Joaquin River and Calaveras River watersheds will pass through the DWSC during any given year. Most of the steelhead in the watersheds of the San Joaquin and Calaveras Rivers move through the region starting in December with the first winter rains. Except for the month of December, it is anticipated that very few steelhead will be present during the dredging work window (June 1 through December 31) based on Stanislaus weir numbers and tributary rotary screw trap data. Therefore, incidental take of Central Valley steelhead originating in the San Joaquin River and Calaveras River watersheds is not expected to exceed 1 percent of the San Joaquin basin population: 1 adult steelhead and 10 juvenile steelhead. At the total population level for the Central Valley steelhead DPS, this anticipated level of incidental take is not expected to exceed 0.02 percent for adults (based on most recent population estimates) and 0.006 percent of naturally-produced juveniles. The numbers of juvenile winter-run and spring-run Chinook salmon that utilize a portion of the San Joaquin River as a migratory corridor are hard to estimate due to the high levels of uncertainty surrounding the division of early migrating fish between the Sacramento River channel and the channels connecting the Sacramento River with the San Joaquin River through the Central Delta. For the past 4 years, the earliest winter-run sized Chinook salmon have not been salvaged at the SWP and CVP pumping facilities until mid-December. Estimates of the population of winter-run sized Chinook salmon entering the Central and South Delta have averaged about 4,800 fish for the 3 month period between October and December, based on extrapolations of the take numbers from the CVP and SWP and a cross-Delta mortality value of 85 percent (higher range estimate) based on the work of Brandes and McLain (2001) and Vogel (2004). Therefore, 4,800 winter-run Chinook salmon are expected to be exposed to these adverse conditions, of which 1 percent will suffer morbidity or mortality (50 fish). This corresponds to a fraction of the population equivalent to reduction by two orders of magnitude of the exposed population. During the same 4-year period of data from the CVP and SWP, spring-run sized fish were not entrained at the pumps until early January. The average number of spring-run sized fish that could potentially be exposed to dredging impacts during December is slightly less than 200 fish per year with the pulse of fish moving through the Delta at the end of December. Using the same rationale, 1 percent of the spring-run Chinook exposed to the adverse conditions will suffer morbidity or mortality (2 fish). No estimates of the population of North American green sturgeon entering the Central and South Delta or San Joaquin River drainage are available, but the number of juveniles and sub-adults taken at the CVP and SWP per year combined has averaged 79 fish. NMFS recently completed a conference opinion assessing the impacts of the IEP fish sampling activities on North American green sturgeon (NMFS 2005c). A total of 265 juvenile or adult North American green sturgeon are anticipated to be taken by 4 of 15 fisheries-related studies. Two of the studies have sampling sites in the Central and South Delta (*i.e.*, Clifton Court Forebay) or the lower San Joaquin River; one of the studies involves year-round sampling. In the absence of definitive data, NMFS estimates that the number of North American green sturgeon taken by the proposed Stockton DWSC Maintenance Dredging and Levee Stabilization project will be 5 percent of the IEP take, which corresponds with the approximate proportion of sampling effort by the IEP in the Central and South Delta or San Joaquin River drainage. Therefore, annual incidental take is estimated to be 14 juvenile, sub-adult, or adult North American green sturgeon per year.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon juveniles harmed, harassed, or killed from altered habitat conditions caused by the maintenance dredging of the Stockton DWSC or stabilization of the levee system along the DWSC. Such conditions may include loss of benthic organism diversity, loss of riparian and shallow water habitat, reduced growth rate, or increased predation risk. Altered habitat is not expected to exceed the footprint of the maintenance dredging or bank stabilization project area as described in the project description included in the BA. Annual values will change according to the needs determination made by the Corps each year.

3. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon juveniles and adults that are harmed or killed from exposure to contaminants resuspended during the maintenance dredging action, and the subsequent discharging of decant water from DMP sites located along the Stockton DWSC that receive the dredge spoils. NMFS anticipates that take of listed salmonids, whether in the form of mortality or morbidity, will occur at contaminant levels below the acute and chronic criteria levels for ammonia, copper, and DO. The anticipated level of contaminant-related mortality is expected to be higher than the mortalities incurred by acoustic and habitat effects. However, except for the month of December, it is anticipated that very few listed salmonids will be present during the dredging work window (June 1 through December 31) based on Stanislaus River weir numbers and tributary rotary screw trap data for steelhead, and salmon monitoring activities conducted by the CDFG and USFWS in the Delta and Sacramento River for winter-run and spring-run Chinook salmon. Therefore, incidental take of Central Valley steelhead originating in the San Joaquin River and Calaveras River watersheds is not expected to exceed 2 percent of the San Joaquin basin population: 2 adult steelhead and 20 juvenile steelhead in any given dredging year. At the total population level for the Central Valley steelhead DPS, this anticipated level of incidental take is not expected to exceed 0.03 percent for adults (based on most recent population estimates) and 0.01 percent of naturally-produced juveniles. Take for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon juveniles is more difficult to quantify, as the proportion of juveniles entering the Central Delta from the Sacramento River is not known precisely. Take may be estimated from the initial zone of dilution for each DMP site outfall (300 feet total length up and downstream from the outfall and not to exceed 50 percent of the cross-section of the receiving water body outwards from the bank). As estimated in subheading (1) above, the average number of winter-run sized Chinook salmon that may potentially be exposed to the decant effluent during the 3 months between October and December is approximately 4,800 fish of which 2 percent are expected to suffer morbidity and mortality (100 fish). Based on the same reasoning, approximately 200 spring-run sized Chinook salmon would be exposed in late December, based on salvage records from the CVP and SWP and expanded by the mortality index of 85 percent for cross-Delta mortality. Of these exposed fish, 2 percent are expected to suffer morbidity or mortality from the dredging action's discharge of decant waters from the DMP sites (4 fish). Annual incidental take of North American green sturgeon is not expected to exceed 14 fish.

4. All North American green sturgeon juveniles that are harmed or killed from entrainment into the hydraulic dredge during its operation. All fish entrained are expected to suffer 100 percent mortality, as they will end up in the DMP site following entrainment. Incidental take of North American green sturgeon is expected to be relatively high (*i.e.*, 10 percent of those exposed) due to their benthic orientation, which will make direct exposure to the dredge cutterhead likely. Annual incidental take of North American green sturgeon is not expected to exceed 2 fish.

5. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles, and North American green sturgeon juveniles, sub-adults, and adults, harmed, harassed, or killed due to the operation of ocean going vessels within the confines of the Corps' maintained ship channel from the Turning Basin in the Port to the mouth of the ship channel at the Port of Pittsburg. Take is expected to occur from the erosion and degradation of the channel bottom resulting in an increase in turbidity and resuspension of contaminated sediments along the length of the DWSC. Based on the best available information and the results of studies conducted by the Corps on the upper Mississippi River, additional take is expected from entrainment by ship propellers and the turbulent flow created by hull passage through the water column. NMFS has estimated that between 450 and 5,000 Sacramento River winter-run Chinook salmon may be adversely affected by propeller entrainment. Due to the large variance in the estimate, incidental take is not expected to exceed the mid-point of this range: 2,500 juvenile Sacramento River winter-run Chinook salmon. NMFS has estimated that approximately 44,000 to 500,000 Central Valley spring-run/fall-run sized juvenile Chinook salmon may be adversely affected by propeller entrainment. Incidental take is not expected to exceed 250,000 spring-run/fall-run sized juvenile Chinook salmon, of which 2 percent (5,000 fish) are expected to be Central Valley spring-run Chinook salmon. NMFS has estimated that between 40 and 500 juvenile Central Valley steelhead from both the Sacramento River and San Joaquin River watersheds may be adversely affected by propeller entrainment. Incidental take is not expected to exceed 250 juvenile steelhead. Incidental take of North American green sturgeon is not expected to exceed 14 fish.

The total incidental take associated with this project is as follows:

Species	Juveniles Number	Juveniles Percent of ESU/DPS	Adults Number	Adults Percent of ESU/DPS
Sacramento River winter-run Chinook salmon:	2,650	0.85	0	0
Central Valley spring-run Chinook salmon:	5,006	0.32	0	0
Central Valley Steelhead:	280	0.15	3	0.15
North American Green Sturgeon	14 Juveniles and Adults Combined			

Other incidental take associated with the operation of ocean going vessels and tugs (*e.g.*, discharges of pollutants from ship engines, introduction of non-native invasive species, *etc.*) is not included in this incidental take statement because the Corps does not have the authority to regulate these activities.

B. Effect of the Take

In the accompanying biological and conference opinion, NMFS determined that the level of anticipated take will not result in jeopardy to the species or destruction or adverse modification of designated critical habitat.

C. Reasonable and Prudent Measures

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon.

1. Measures shall be taken to avoid, minimize, and monitor the impacts of maintenance dredging upon listed salmonids, North American green sturgeon, and their habitat.

2. Measures shall be taken to avoid, minimize, and monitor the impacts of levee stabilization activities upon listed salmonids, North American green sturgeon, and their habitat.

3. Measures shall be taken to monitor the impacts to listed salmonids, North American green sturgeon, and their habitat from the operations of ocean going vessels within the DWSC from the Port of Pittsburg to the Turning Basin in the Port.

4. Pending the listing of the southern DPS of North American green sturgeon, the Corps will implement additional measures to avoid, minimize, and monitor incidental take of North American green sturgeon from dredging and disposal activities.

D. Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the action must be implemented in compliance with the following terms and conditions, which implement the reasonable and prudent measures described above for each category of activity. These terms and conditions are non-discretionary.

1. Measures shall be taken to avoid, minimize, and monitor the impacts of maintenance dredging upon listed salmonids, North American green sturgeon, and their habitat.

a) Dredging operations shall be conducted within the specified work window of June 1 to December 31. If dredging is necessary outside of this window, NMFS will be contacted for approval at least 30 days prior to the activity. The request must be written and include the location and size of the work area within the Stockton DWSC, and estimates of the amount of time required and dredging material to be removed. The request is to be sent to the following address:

Attn: Supervisor
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, California 95814-4706

Office: (916) 930-3601
Fax: (916) 930-3629

b) Maintenance dredging outside of the specified work window of June 1 to December 31 may require the following additional protective measures:

i) Silt curtains may be employed to surround the dredging area to prevent the spread of suspended sediments into the migration corridor of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon.

ii) The Corps may be required to monitor the underwater acoustic noise output of the dredging actions. Sound generated by the dredging action shall not exceed 145 db (ref 1µPa) at one meter depth and ten meters range from the dredge. Noise attenuation methods may be employed to reduce the noise level to acceptable levels.

iii) The Corps and Port will be required to visually monitor the waterway adjacent to the dredge area (*i.e.*, within 300 feet) for any affected fish including, but not limited to, Central Valley steelhead. Observation of one or more affected fish will be reported to NMFS at the address above within 24 hours of the incident. The Corps and Port will coordinate with NMFS to determine the cause of the incident and whether any additional protective measures are necessary to protect Central Valley steelhead. These protective measures shall be implemented within 72 hours of the incident. Affected fish are defined as:

(1) Dead or moribund fish at the water surface;
(2) Show signs of erratic swimming behavior or other obvious signs of distress;
(3) Gasping at the surface; or
(4) Show signs of other unusual behavior.

c) Maintenance dredging shall be implemented exactly as described in the BA and supplemental information package received by NMFS, and summarized on pages 2 through 5 of this biological opinion, including implementation of all applicable conservation measures listed on pages 6 through 9 of this biological opinion. NMFS shall be notified in advance of any proposed changes to determine if reinitiation of consultation or implementation of additional protective measures for fish may be necessary. Prior to each dredging season, the Corps shall provide NMFS documentation of exact reaches of the Stockton DWSC proposed for maintenance dredging, schedules for that dredging year, and which DMP sites are to be used. At the completion of each dredging season, the Corps shall provide NMFS documentation of the exact reaches of the Stockton DWSC that were dredged, and which DMP sites were used. Also, NMFS shall be sent copies of any sediment, effluent, or water quality monitoring reports required by the Regional Board that are related to the dredging actions of this project at the address above within 60 days of their completion.

d) Final drafts of the Corps' proposed plans for fisheries monitoring and water quality monitoring programs shall be completed prior to the start of the 2007 maintenance dredging season, and will include adaptive management strategies. All activities related to scope identification (*i.e.*, goals, milestones for completion, check-in points, triggers for management change (management decision points that include specific metrics), and sampling/testing protocols to be developed) will be coordinated with NMFS.

2. Measures shall be taken to avoid, minimize, and monitor the impacts of levee stabilization activities upon listed salmonids, North American green sturgeon, and their habitat.

a) Levee stabilization activities shall be implemented exactly as described in the BA and supplemental information package received by NMFS, and summarized on pages 5 through 6 of this biological opinion, including implementation of all applicable conservation measures listed on pages 6 through 9 of this biological opinion. NMFS shall be notified in advance of any proposed changes to determine if reinitiation of consultation or implementation of additional protective measures for fish may be necessary.

b) The conceptual models of the Standard Assessment Methodology (SAM; Corps 2004) shall be applied to the proposed action to design specific bank stabilization activities that will minimize impacts to listed species. The SAM was developed by the Corps, in collaboration with NMFS, the California Department of Fish and Game, the California Department of Water Resources, and the U.S. Fish and Wildlife Service, to quantify impacts to listed fish species and their habitat from large bank protection projects. The SAM represents the best available scientific approach for assessing the effects of bank protection actions to listed anadromous fish and their habitat.

3. Measures shall be taken to monitor the impacts to listed salmonids, North American green sturgeon, and their habitat from the operations of ocean going vessels within the DWSC from the Port of Pittsburg to the Turning Basin in the Port.

a) The Corps shall develop and initiate studies to ascertain the extent of propeller entrainment for listed salmonids and North American green sturgeon within the DWSC. These studies should be coordinated with those required of the Port of Stockton in NMFS (2005c), and can be performed in conjunction with studies associated with the John F. Baldwin DWSC to Stockton studies and/or the new Delta Long-term Management Strategy (LTMS). The studies may include, but are not limited to:

i) Assessment of hull related shear forces and turbulence created by passing ships within the channel of the DWSC, including their zones of influence;

ii) Defining the zone of inflow surrounding the hulls of ships in which fish can be entrained into the ship's propeller(s);

iii) Defining the zone around a passing ship in which fish react to the hull's presence and passage; and,

iv) Assessment of the proportion of fish, including listed salmonids, which are impacted by the passage of ocean going ships, including direct effects of the propeller disc and the turbulence fields surrounding the ship.

b) The Corps shall develop and initiate studies to examine the impact of ship passage on the resuspension of channel sediments and their impact on water quality within the DWSC. These studies should be coordinated with those required of the Port of Stockton in NMFS (2005c), and can be performed in conjunction with studies associated with the John F. Baldwin DWSC to Stockton studies and/or the new LTMS. The studies may include, but are not limited to answering the following questions:

i) What is the volume/mass of sediment resuspended by the passage of ships in the DWSC in both loaded and unloaded configurations during the year, broken down by month?

ii) How is this amount of sediment related to "natural" sediment loads in the DWSC?

iii) What are the settling rates of the different sediment types in the DWSC and how does ship passage affect the time that these sediments remain suspended in the water column?

iv) How does the resuspension of sediments, including those which are contaminated, affect the health of the aquatic organisms in the DWSC, including listed salmonids and their forage base?

v) How does the resuspension of sediments affect the water quality in the DWSC? Water quality parameters to be examined include: DO levels, redox cycling in suspended materials, and nutrient loads.

c) The Corps will make available to NMFS all study plans for review, comment, and approval prior to implementation by June 1, 2008. NMFS, at its discretion, may seek independent scientific peer review of these study plans and their future findings for scientific soundness. Coordination with CALFED studies, academic institutions, and other State and Federal research is highly encouraged and recommended.

d) All findings will be made available to NMFS upon completion of the studies. Reports will be sent to the address in 1(a) within 60 days after they become available.

4. **Pending the listing of the southern DPS of North American green sturgeon, the Corp will implement additional measures to avoid, minimize, and monitor incidental take of North American green sturgeon from dredging and disposal activities.**

   a) The Corps will monitor take of green sturgeon, and if necessary within 5 years develop methodologies to reduce or eliminate the entrainment of green sturgeon during hydraulic dredging operations. Such methodology may be in the form of exclusion devices similar to turtle boxes, or wire "ticklers" to move fish away from the cutterhead. The Corps will work with NMFS to develop and test these devices.

   b) The Corps will monitor take of green sturgeon, and if necessary within 5 years will study the potential for sediment contaminants to affect benthic-oriented fish such as sturgeon. Such studies will examine direct exposures, such as through dermal contact or ingestion, or indirect exposure through the forage base.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The Corps should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage its contractors to modify operation and maintenance procedures through the Corps' authorities so that those actions avoid or minimize negative impacts to salmon and steelhead.

2. The Corps should support anadromous salmonid monitoring programs throughout the Delta and Suisun Bay to improve the understanding of migration and habitat utilization by salmonids in this region.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the actions outlined in the April 15, 2005, request for consultation received from the Corps. This biological opinion is valid for the Stockton DWSC Maintenance Dredging and Levee Stabilization project described in the BA and supplemental information package received by NMFS. As provided for in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in any incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

This concludes formal conferencing on the action described in the BA and supplemental information package received by NMFS for the Stockton DWSC Maintenance Dredging and Levee Stabilization project. You may ask NMFS to confirm the conference opinion as a biological opinion issued through formal consultation if the southern DPS of North American green sturgeon is listed as threatened. The request must be in writing. If NMFS reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, NMFS will confirm the conference opinion as the biological opinion for the project and no further section 7 consultation will be necessary.

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Appendix A: Tables

Table 5.

Monthly Occurrences of Dissolved Oxygen Depressions below the 5mg/L Criteria in the Stockton Deepwater Ship Channel (Rough and Ready Island DO monitoring site) Water Years 2000 to 2004

			Water Year			
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2*	0	2	4	0	8
Yearly Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Table 6. Salmon and Steelhead monitoring programs in the Sacramento - San Joaquin River basins, and Suisun Marsh.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook salmon, Steelhead***	Sacramento River	Scale and otolith collection	Coleman National Hatchery, Sacramento River and tributaries	Scale and otolith microstructure analysis	Year-round	CDFG
		Sacramento River and San Joaquin River	Central Valley angler survey	Sacramento and San Joaquin rivers and tributaries downstream to Carquinez	In-river harvest	8 or 9 times per month, year-round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at Balls Ferry and Deschutes Road Bridge	Juvenile emigration timing and abundance	Year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at RBDD	Juvenile emigration timing and abundance	Year round	FWS
		Sacramento River	Ladder counts	Upper Sacramento River at RBDD	Escapement estimates, population size	Variable, May - Jul	FWS
		Sacramento River	Beach seining	Sacramento River, Caldwell Park to Delta	Spatial and temporal distribution	Bi-weekly or monthly, year-round	FWS
		Sacramento River	Beach seining, snorkel survey, habitat mapping	Upper Sacramento River from Battle Creek to Caldwell Park	Evaluate rearing habitat	Random, year-round	CDFG
		Sacramento River	Rotary screw trap	Lower Sacramento River at Knight's Landing	Juvenile emigration and post-spawner adult steelhead migration	Year-round	CDFG
		Sacramento-San Joaquin basin	Kodiak/Midwater trawling	Sacramento River at Sacramento, Chipps Island, San Joaquin River at Mossdale	Juvenile outmigration	Variable, year-round	FWS
		Sacramento-San Joaquin Delta	Kodiak trawling	Various locations in the Delta	Presence and movement of juvenile salmonids	Daily, Apr - Jun	IEP
		Sacramento-San Joaquin Delta	Kodiak trawling	Jersey Point	Mark and recapture studies on juvenile salmonids	Daily, Apr - Jun	Hanson Environmental Consultants
Central Valley	***Chinook salmon, Steelhead, Continued***	Sacramento-San Joaquin Delta	Salvage sampling	CVP and SWP south Delta pumps	Estimate salvage and loss of juvenile salmonids	Daily	USBR/CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Battle Creek	Rotary screw trap	Above and below Coleman Hatchery barrier	Juvenile emigration	Daily, year-round	FWS
		Battle Creek	Weir trap, carcass counts, snorkel/ kayak survey	Battle Creek	Escapement, migration patterns, demographics	Variable, year-round	FWS
		Clear Creek	Rotary screw trap	Lower Clear Creek	Juvenile emigration	Daily, mid Dec- Jun	FWS
		Feather River	Rotary screw trap, Beach seining, Snorkel survey	Feather River	Juvenile emigration and rearing, population estimates	Daily, Dec - Jun	DWR
		Yuba River	Rotary screw trap	lower Yuba River	Life history evaluation, juvenile abundance, timing of emergence and migration, health index	Daily, Oct - Jun	CDFG
		Feather River	Ladder at hatchery	FRH	Survival and spawning success of hatchery fish (spring-run Chinook salmon), determine wild vs. hatchery adults (steelhead)	Variable, Apr - Jun	DWR, CDFG
		Mokelumne River	Habitat typing	Lower Mokelumne River between Camanche Dam and Cosumnes River confluence	Habitat use evaluation as part of limiting factors analysis	Various, when river conditions allow	EBMUD
		Mokelumne River	Redd surveys	Lower Mokelumne River between Camanche Dam and Hwy 26 bridge	Escapement estimate	Twice monthly, Oct 1- Jan 1	EBMUD
		Mokelumne River	Rotary screw trap, mark/recapture	Mokelumne River, below Woodbridge Dam	Juvenile emigration and survival	Daily, Dec- Jul	EBMUD
		Mokelumne River	Angler survey	Lower Mokelumne River below Camanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD
<u>Central Valley</u>	***Chinook salmon, Steelhead, Continued***	Mokelumne River	Beach seining, electrofishing	Lower Mokelumne	Distribution and habitat use	Various locations at various times throughout the year	EBMUD
		Mokelumne River	Video monitoring	Woodbridge Dam	Adult migration timing, population estimates	Daily, Aug - Mar	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Calaveras River	Adult weir, snorkel survey, electrofishing	Lower Calaveras River	Population estimate, migration timing, emigration timing	Variable, year-round	Fishery Foundation
		Stanislaus River	Rotary screw trap	lower Stanislaus River at Oakdale and Caswell State Park	Juvenile outmigration	Daily, Jan - Jun, dependent on flow	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel surveys, hook and line survey, beach seining, electrofishing	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence and distribution, habitat use, and abundance	Variable, Mar- Jul	CDFG
	Central Valley Steelhead	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	CNFH	Returns to hatchery	Daily, Jul 1 - Mar 31	FWS
		Clear Creek	Snorkel survey, redd counts	Clear Creek	Juvenile and spawning adult habitat use	Variable, dependent on river conditions	FWS
		Mill Creek, Antelope Creek, Beegum Creek	Spawning survey - snorkel and foot	Upper Mill, Antelope, and Beegum Creeks	Spawning habitat availability and use	Random days when conditions allow, Feb - Apr	CDFG
		Mill Creek, Deer Creek, Antelope Creek	Physical habitat survey	Upper Mill, Deer, and Antelope Creeks	Physical habitat conditions	Variable	USFS
		Dry Creek	Rotary screw trap	Miner and Secret Ravine's confluence	Downstream movement of emigrating juveniles and post-spawner adults	Daily, Nov- Apr	CDFG
		Dry Creek	Habitat survey, snorkel survey, PIT tagging study	Dry Creek, Miner and Secret Ravine's	Habitat availability and use	Variable	CDFG
Central Valley	***Central Valley Steelhead Continued***	Battle Creek	Otolith analysis	CNFH	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	FWS
		Feather River	Hatchery coded wire tagging	FRH	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Feather River	Snorkel survey	Feather River	Escapement estimates	Monthly, Mar to Aug (upper river), once annually (entire river)	DWR
		Yuba River	Adult trap	lower Yuba River	Life history, run composition, origin, age determination	Year-round	Jones and Stokes
		American River	Rotary screw trap	Lower American River, Watt Ave. Bridge	Juvenile emigration	Daily, Oct- Jun	CDFG
		American River	Beach seine, snorkel survey, electrofishing	American River, Nimbus Dam to Paradise Beach	Emergence timing, juvenile habitat use, population estimates	Variable	CDFG
		American River	Redd surveys	American River, Nimbus Dam to Paradise Beach	Escapement estimates	Once, Feb - Mar	CDFG, BOR
		Mokelumne River	Electrofishing, gastric lavage	Lower Mokelumne River	Diet analysis as part of limiting factor analysis	Variable	EBMUD
		Mokelumne River	Electrofishing, hatchery returns	Lower Mokelumne River, Mokelumne River hatchery	O. Mykiss genetic analysis to compare hatchery returning steelhead to residents	Variable	EBMUD
		Calaveras River	Rotary screw trap, pit tagging, beach seining, electrofishing	lower Calaveras River	Population estimate, migration patterns, life history	Variable, year-round	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel survey, hook and line survey, beach seining, electrofishing, fish traps/weirs	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence, origin, distribution, habitat use, migration timing, and abundance	Variable, Jun - Apr	CDFG
		Merced River	Rotary screw trap	Lower Merced River	Juvenile outmigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.
Central Valley	***Central Valley Steelhead Continued***	Central Valley-wide	Carcass survey, hook and line survey, electrofishing, traps, nets	Upper Sacramento, Yuba, Mokelumne, Calaveras, Tuolumne, Feather, Cosumnes, and Stanislaus Rivers, and Mill, Deer, Battle, and Clear Creeks	Occurrence and distribution of *O. Mykiss*	Variable, year-round	CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Central Valley - wide	Scale and otolith sampling	Coleman NFH, Feather, Nimbus, Mokelumne River hatcheries	Stock identification, juvenile residence time, adult age structure, hatchery contribution	Variable upon availability	CDFG
		Central Valley - wide	Hatchery marking	All Central Valley Hatcheries	Hatchery contribution	Variable	FWS, CDFG
	Sacramento River Winter-run Chinook salmon	Sacramento River	Aerial redd counts	Keswick Dam to Princeton	Number and proportion of reds above and below RBDD	Weekly, May 1-July 15	CDFG
		Sacramento River	Carcass survey	Keswick Dam to RBDD	In-river spawning escapement	Weekly, Apr 15-Aug 15	FWS, CDFG
		Battle Creek	Hatchery marking	Coleman National Fish Hatchery	Hatchery contribution	Variable	FWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	FWS
		Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	Central Valley Spring-run Chinook salmon	Mill, Deer, Antelope, Cottonwood, Butte, Big Chico Creeks	Rotary screw trap, snorkel survey, electrofishing, beach seining	upper Mill, Deer, Antelope, Cottonwood, Butte, and Big Chico creeks	Life history assessment, presence, adult escapement estimates	Variable, year-round	CDFG
		Feather River	Fyke trapping, angling, radio tagging	Feather River	Adult migration and holding behavior	Variable, Apr-June	DWR
		Yuba River	Fish trap	lower Yuba River, Daguerre Point Dam	Timing and duration of migration, population estimate	Daily, Jan - Dec	CDFG
Suisun Marsh	***Chinook salmon***	Suisun Marsh	Otter trawling, beach seining	Suisun Marsh	Relative population estimates and habitat use	Monthly, year-round	UC Davis
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Appendix B: Figures

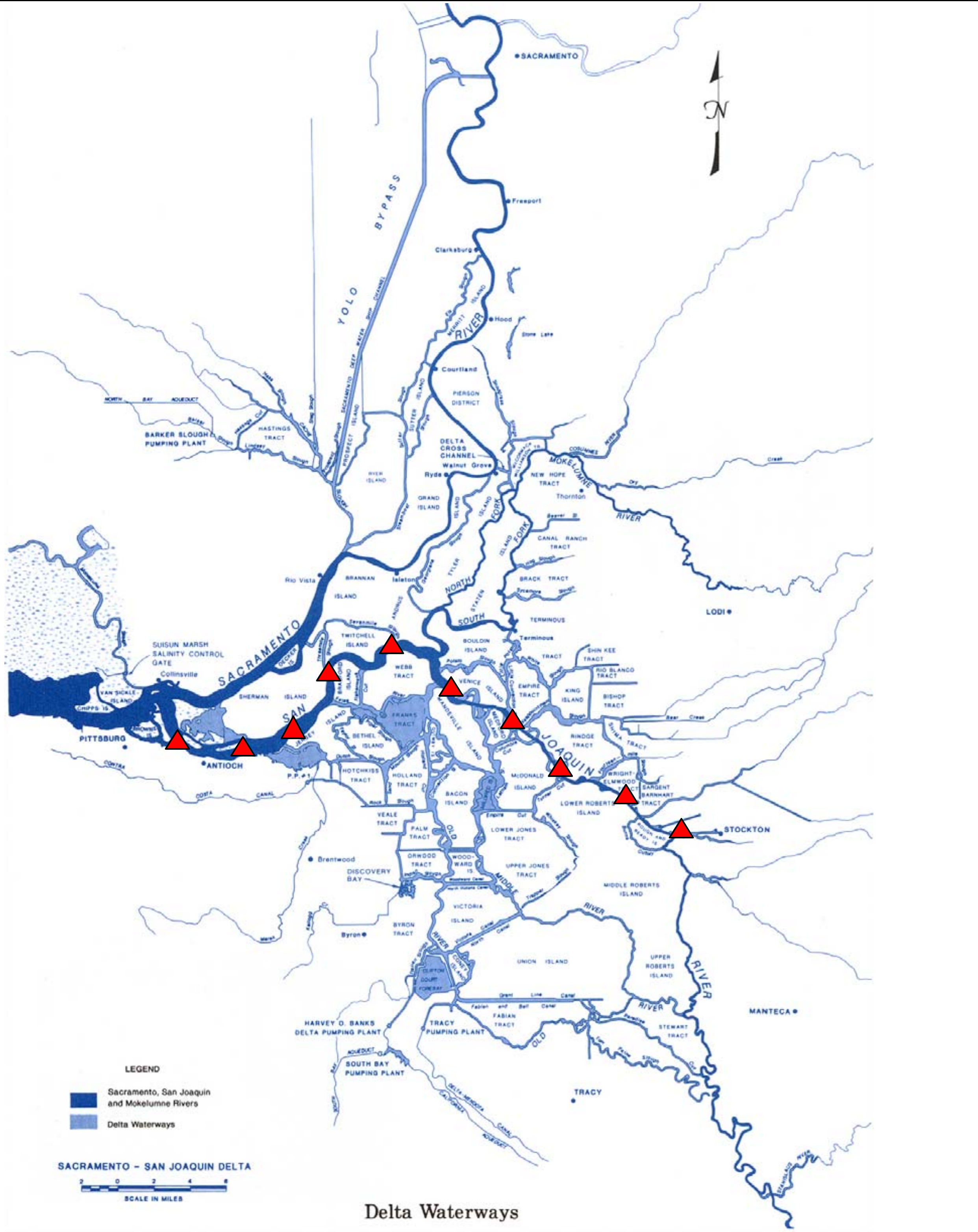


Figure 1: Stockton DWSC Dredging Action Area shown by triangles.

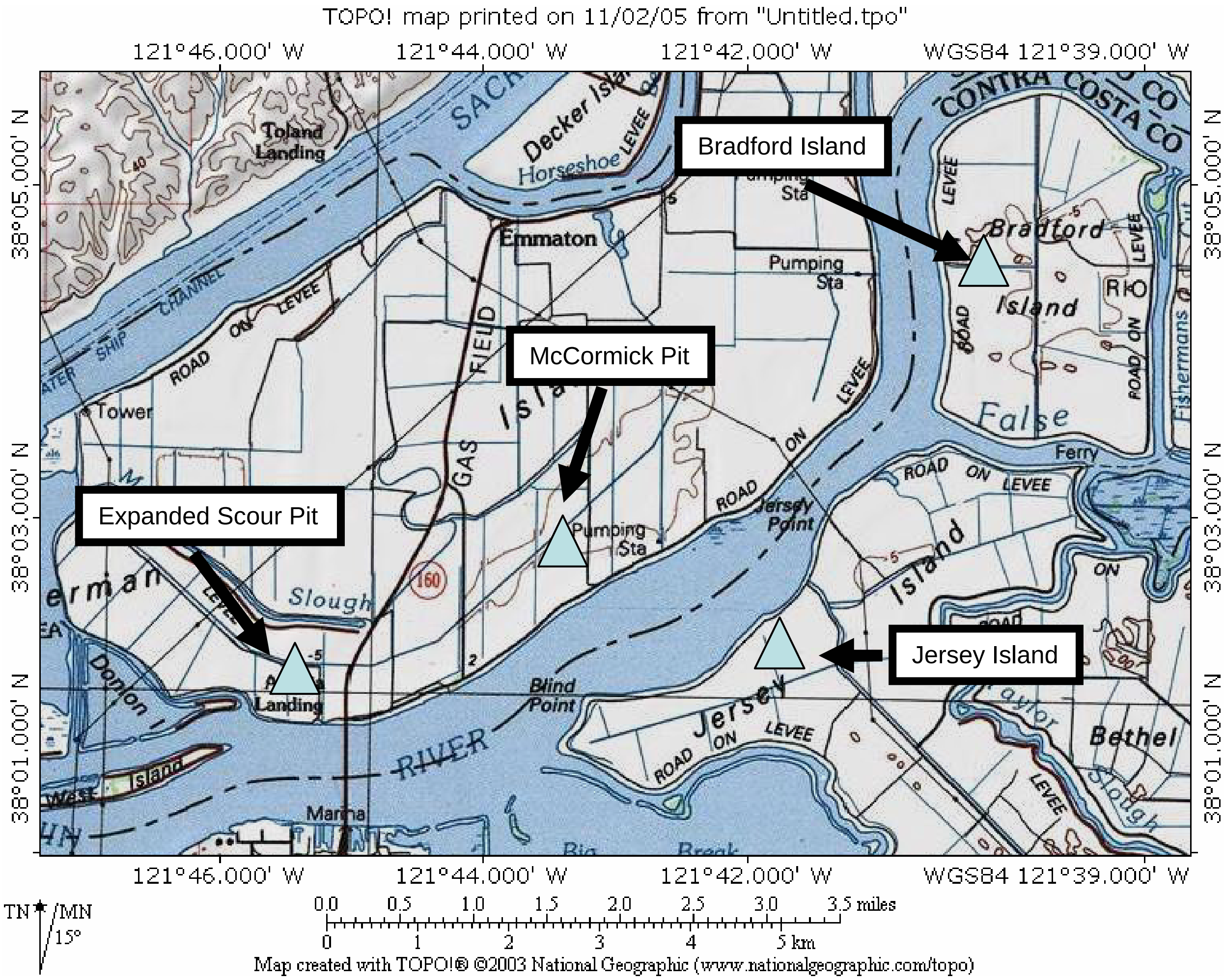


Figure 2a: DMP Sites in western portion of the action area

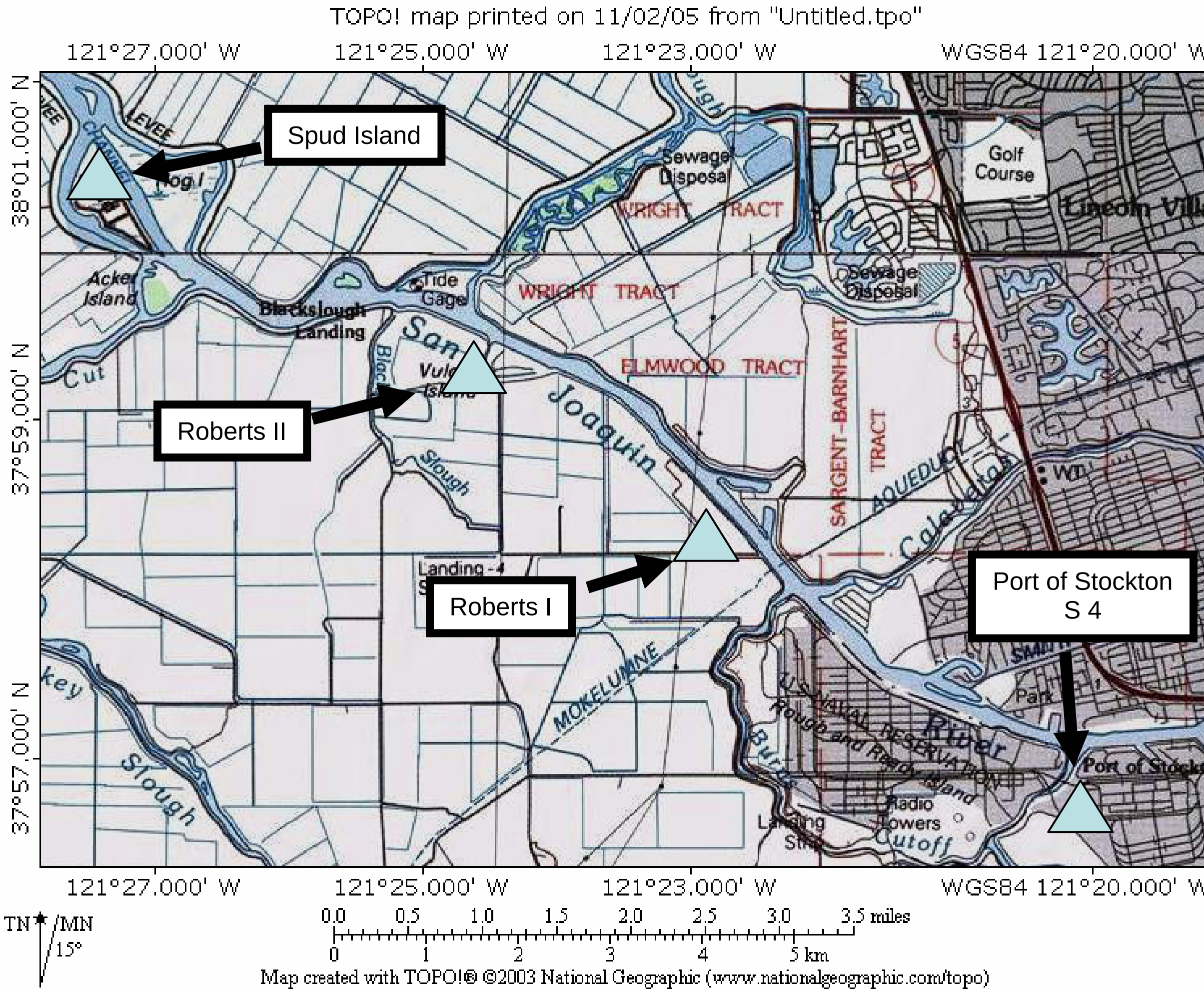


Figure 2b: DMP sites in eastern portion of action area

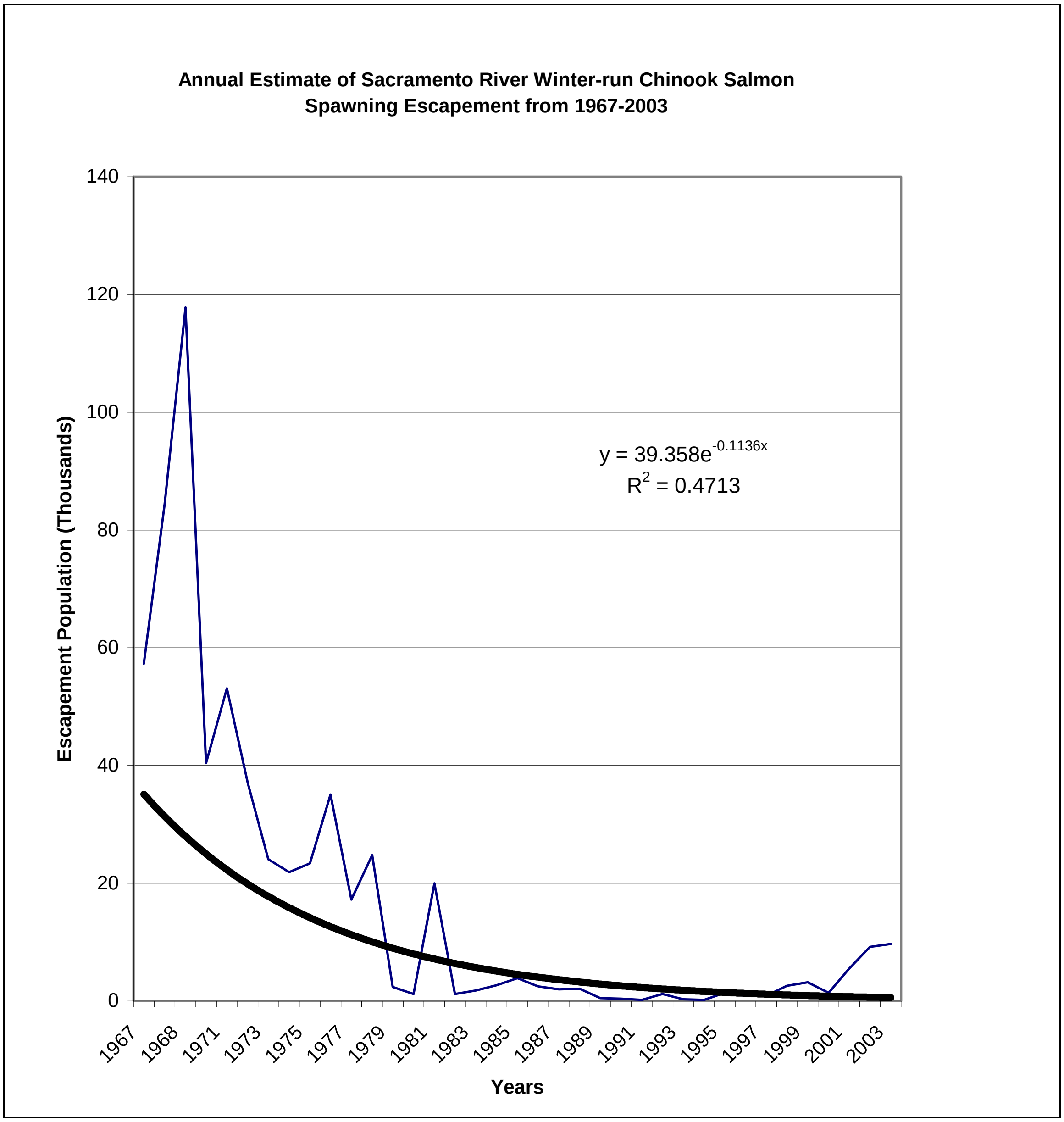


Figure 3:
Annual estimated Sacramento River winter-run Chinook salmon escapement population.
Sources: PFMC 2002, DFG 2004a, NMFS 1997
Trendline for figure 5 is an exponential function: $Y=39.358\ e^{-0.1136x}$, $R^2=0.4713$.

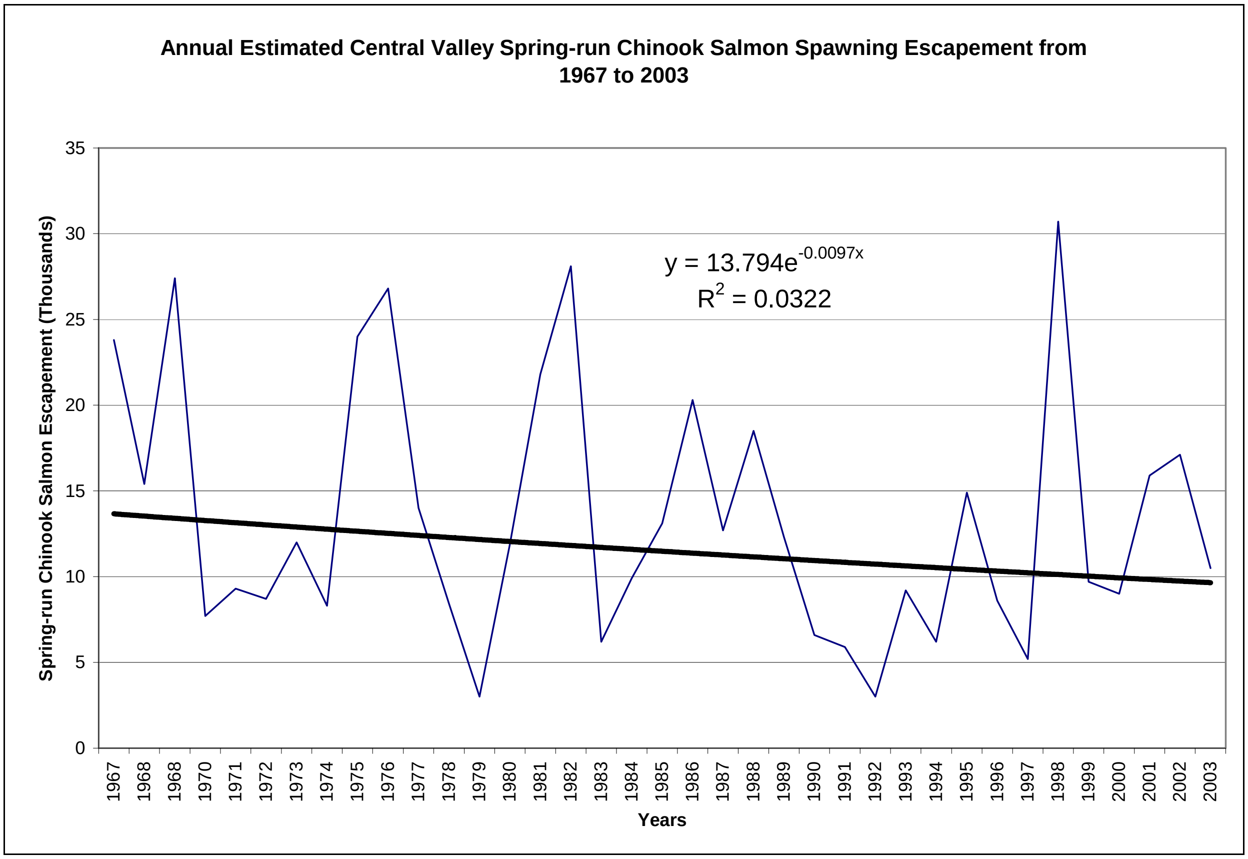
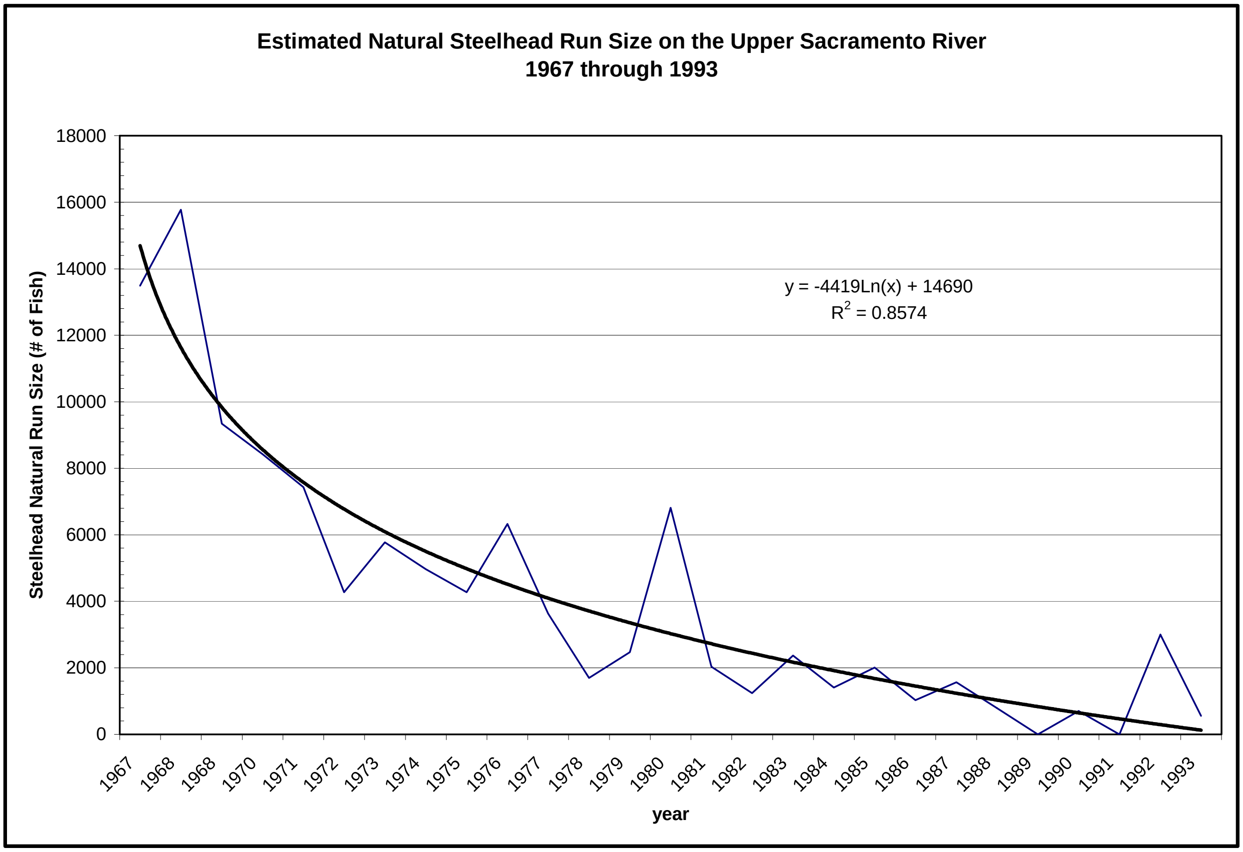


Figure 4:
Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1967 through 2003.
Sources: PFMC 2002, DFG 2004b, Yoshiyama 1998.
Trendline for figure 6 is an exponential function: $Y=13.794\ e^{-0.0097}$, $R^2 = 0.0322$.



Note: Steelhead escapement surveys at RBDD ended in 1993

Figure 5:
Estimated Central Valley natural steelhead escapement population in the upper Sacramento River based on RBDD counts.
Source: McEwan and Jackson 1996.
Trendline for Figure 7 is a logarithmic function: Y= -4419 Ln(x) + 14690 R^2= 0.8574

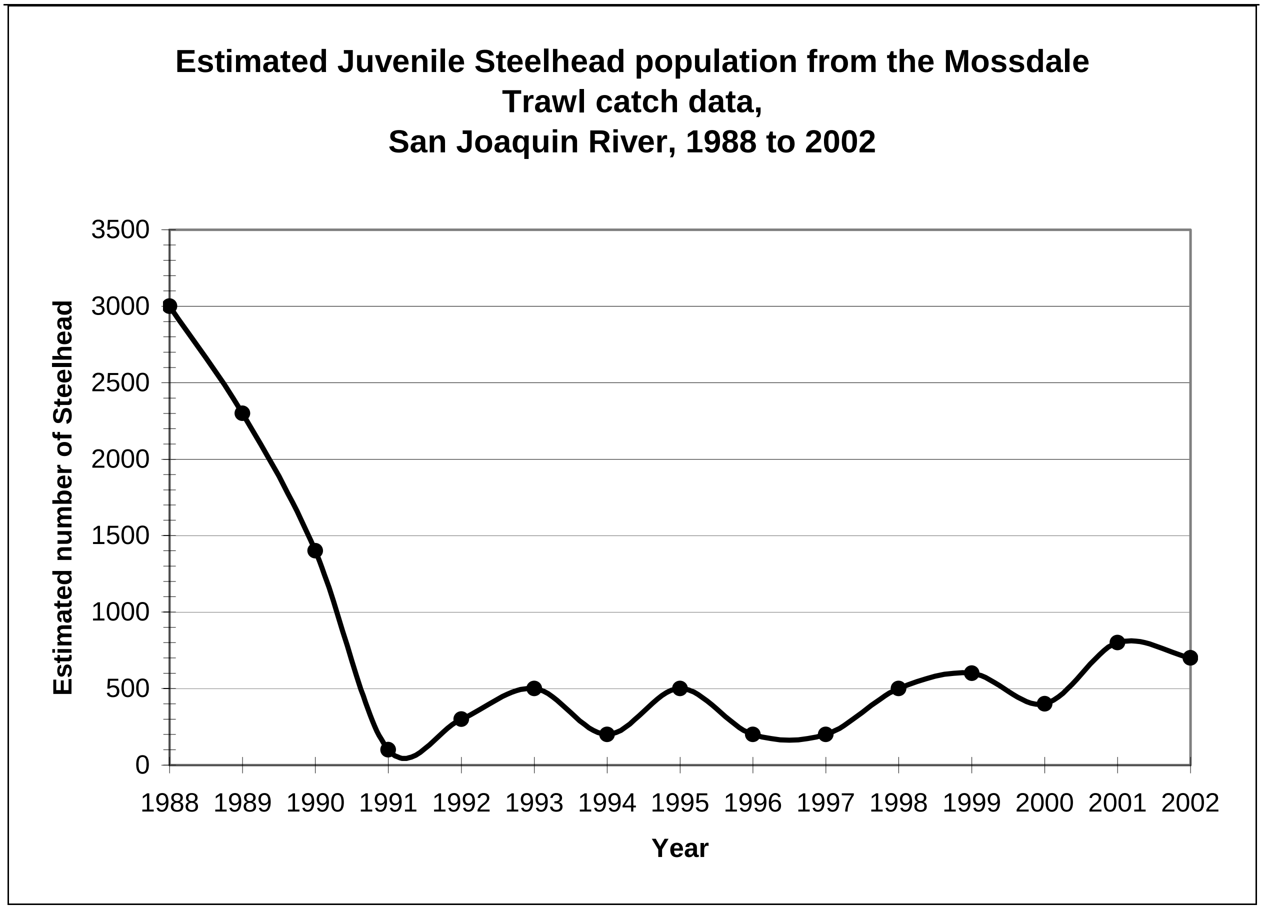


Figure 6:
Estimated number of juvenile Central Valley steelhead derived from the Mossdale trawl surveys on the San Joaquin River from 1988 to 2002.
Source: Marston (DFG), 2003.

Figure 7: Transformation and Transport of a Chemical in an Aquatic Environment
(Figure based on illustration in Rand [1995], page 450)

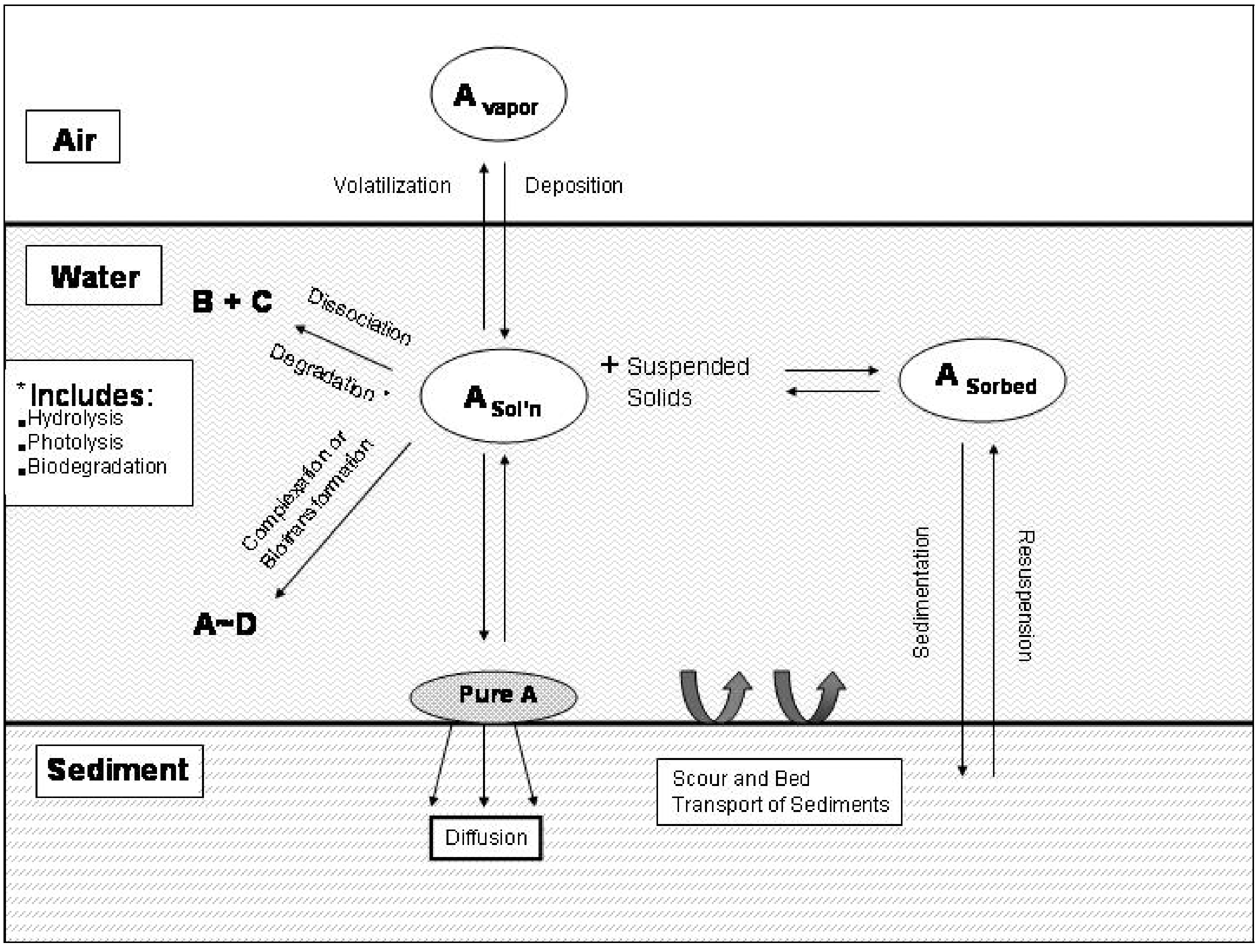


Figure 7 represents a cartoon of the generalized transformation and transportation processes of a chemical in an aquatic environment. Symbols "B" and "C" represent degradation products of chemical "A" and symbol "D" represents a ligand that complexes with or joins to compound A. For example, a proportion of the NH_3 present in the water column in solution would form NH_4^+ via hydrolysis under the influence of the ambient pH in the water column. The ammonium ion (NH_4^+) could then be transformed by microbial action into nitrite (NO_2^-) and then nitrate (NO_3^{-2}) ions. Likewise, the element copper could enter the aquatic environment from the sediment through resuspension and proceed through different pathways to affect aquatic organisms as a free or complexed metal ion.

Enclosure 2

<u>Magnuson-Stevens Fishery Conservation and Management Act</u>

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.S.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NOAA's National Marine Fisheries Service (NMFS) on any activity which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP and for starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) in Amendment 11 to the Pacific Coast Groundfish FMP.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003), Suisun Bay hydrologic unit (18050001) and the Lower Sacramento hydrologic unit (18020109). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the Delta, Suisun Bay, and Lower Sacramento units.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, riprapping, *etc*. (Dettman *et al.* 1987;

California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b). Factors affecting salmon populations in Suisun Bay include heavy industrialization within its watershed and discharge of wastewater effluents into the bay. Loss of vital wetland habitat along the fringes of the bay reduce rearing habitat and diminish the functional processes that wetlands provide for the bay ecosystem.

A. Life History and Habitat Requirements

1. Pacific Salmon

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding biological opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon Evolutionarily Significant Units (ESUs) are available in the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESUs of Chinook salmon (63 FR 11482).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through December and spawn from October through December while adult Central Valley late fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from October to April and spawn from January to April (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NMFS 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

2. Starry Flounder

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larva to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the anthropogenic contaminants found in the environment.

3. English Sole

The English sole is a flatfish found from Mexico to Alaska. It is the most abundant flatfish in Puget Sound, Washington and is abundant in the San Francisco Bay estuary system. Adults are found in nearshore environments. English sole generally spawn during late fall to early spring at depths of 50 to 70 meters over soft mud bottoms. Eggs are initially buoyant, and then begin to sink just prior to hatching. Incubation may last only a couple of days to a week depending on temperature. Newly hatched larvae are bilaterally symmetrical and float near the surface. Wind and tidal currents carry the larvae into bays and estuaries where the larvae undergo metamorphosis into the demersal juvenile. The young depend heavily on the intertidal areas, estuaries, and shallow near-shore waters for food and shelter. Juvenile English sole primarily feed on small crustaceans (*i.e.* copepods and amphipods) and on polychaete worms in these rearing areas. Polluted estuaries and wetlands decrease the survival rate for juvenile English soles. The juveniles also have a tendency to accumulate many of the contaminants found in their environment and this exposure manifests itself as tumors, sores, and reproductive failures.

II. PROPOSED ACTION

The proposed action is described in section II (*Description of the Proposed Action*) of the preceding biological opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead (*O. mykiss*), proposed threatened southern Distinct Population Segment of North American green sturgeon, and designated critical habitat for Central Valley steelhead (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on salmonid habitat (*i.e.*, for winter, spring and fall/late fall-run Chinook salmon) are described at length in section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH. The general contaminant effects on the quality of EFH for the two species of flatfish are expected to be similar to those for green sturgeon due to their benthic life history. Benthic dwelling flatfish will have direct contact with contaminated sediment and will ingest sediment as well as benthic invertebrates during their foraging activities. Both the starry flounder and the English sole will spend more time as juveniles rearing in the action area than the Chinook salmon smolts. Therefore, these fish species will have a greater duration of exposure to the contaminants of concern than the juvenile Chinook salmon, leading to greater levels of adverse effects to the individual organisms.

IV. CONCLUSION

Based on the best available information, NMFS believes that the proposed Stockton Deep Water Ship Channel Maintenance Dredging and Levee Stabilization project may adversely affect EFH for Pacific salmon and groundfish during its initial and normal long-term operations.

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that the reasonable and prudent measures 1 and 2 from the biological opinion, with their associated terms and conditions, be adopted as EFH Conservation Recommendations for EFH in the action area. In addition, certain other conservation measures need to be implemented in the project area, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS anticipates that implementing those conservation measures intended to minimize disturbance and sediment and pollutant inputs to waterways would benefit groundfish as well.

Riparian Habitat Management–In order to prevent adverse effects to riparian corridors, the U.S. Army Corps of Engineers (Corps) should:

- Maintain riparian management zones of appropriate width in the San Joaquin River and Calaveras River watersheds that influence EFH;
- Reduce erosion and runoff into waterways within the project area; and
- Minimize the use of chemical treatments within the riparian management zone to manage nuisance vegetation along the levee banks and reclamation district's irrigation drain.

Bank Stabilization–The installation of riprap or other streambank stabilization devices can reduce or eliminate the development of side channels, functioning riparian and floodplain areas and off channel sloughs. In order to minimize these impacts, the Corps should:

- Use vegetative methods of bank erosion control whenever feasible. Hard bank protection should be a last resort when all other options have been explored and deemed unacceptable;
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species before planning new bank stabilization projects; and
- Develop plans that minimize alterations or disturbance of the bank and existing riparian vegetation.

Conservation Measures for Construction/Urbanization–Activities associated with urbanization (*e.g.*, building construction, utility installation, road and bridge building, and storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and subsequently adversely impact salmon EFH through habitat loss or modification. In order to minimize these impacts, the Corps and the applicant should:

- Plan development sites to minimize clearing and grading;

- Use Best Management Practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoid building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients; and

- Where feasible, reduce impervious surfaces.

Wastewater/Pollutant Discharges–Water quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (*e.g.*, from dredging or ship traffic), and when flow is altered. Indirect sources of water pollution in salmon habitat includes run-off from streets, yards, and construction sites. In order to minimize these impacts, the Corps and the applicant should:

- Monitor water quality discharge following National Pollution Discharge Elimination System requirements from all discharge points;

- For those waters that are listed under Clean Water Act section 303 (d) criteria (*e.g.*, the Delta), work with State and Federal agencies to establish total maximum daily loads and develop appropriate management plans to attain management goals; and

- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling and transport of toxic substances in salmon EFH (*e.g.*, oil and fuel, organic solvents, raw cement residue, sanitary wastes, *etc*.). Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the Federal lead agency provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR §600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

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